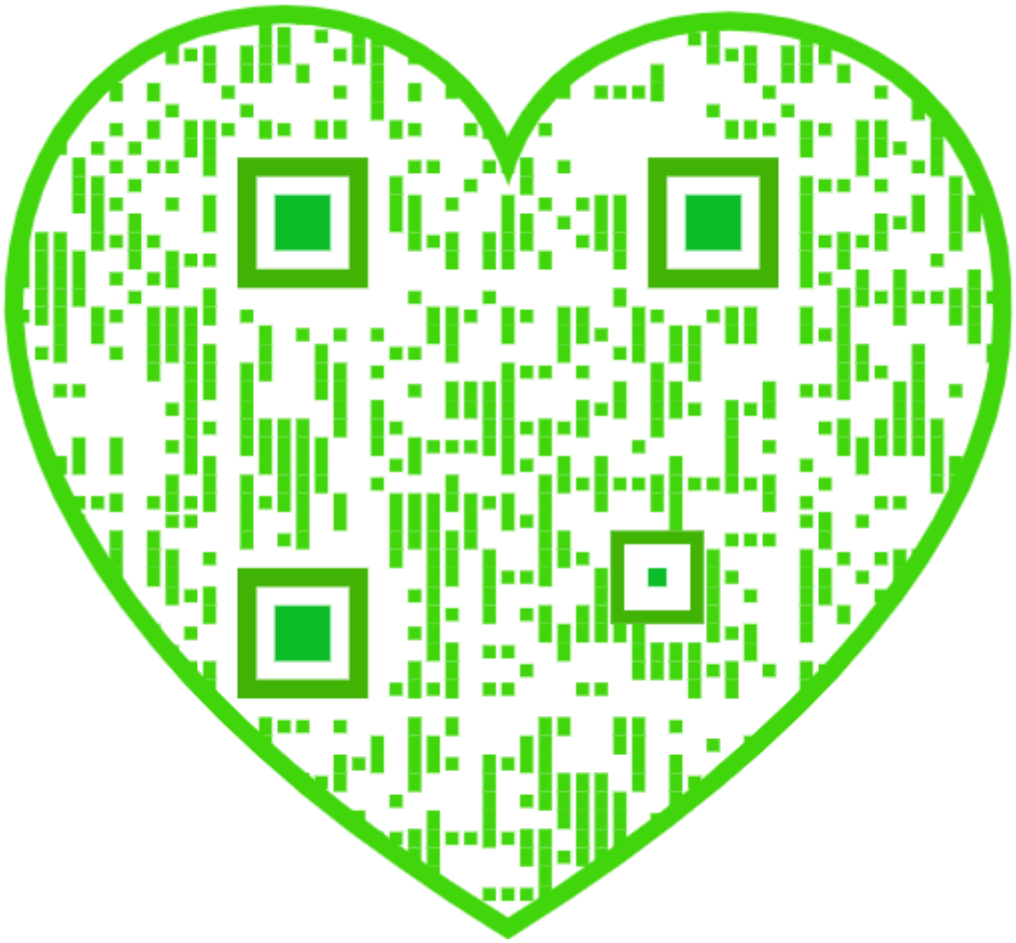
HOUSEHOLD CHEMISTRY

BY

H. T. VULTÉ and G. A. GOODELL



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LABORATORY NOTES

IN

HOUSEHOLD CHEMISTRY

FOR THE USE OF

STUDENTS IN DOMESTIC SCIENCE

BY

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EASTON, PA.:
THE CHEMICAL PUBLISHING COMPANY.
1904.

Two Copies Received
OCT 26 1904
Copyright Entry
Sep. 21, 1904
CLASS A XXo. No.
97073
COPY B

PREFACE.

The following pages are written as a guide and introduction to the study of household science. It is not the object of the authors to put forth a work on the analysis of food and other kindred subjects met with in the practice of domestic science; their sole aim is to throw some light upon the composition of food and other materials to the end that those practicing this most useful of arts may achieve better results by understanding the more important properties of materials with which they deal.

Some knowledge of chemistry, both general and organic, is necessary and a clear idea of the essentials of physics is indispensable.

It is hoped that teachers using the manual will communicate with the authors in regard to any suggestions or improvements.

The book is a pioneer in the subject and may be criticized on account of the selection of subjects; they are, however, those which have in the course of three years proved most useful to the authors' classes.

The common and metric systems of weights and measures are used in the manual; in all exact experiments the metric system has been given the preference, but in cases where the experiment has a direct bearing on domestic science the common household units have been brought into play.

CONSTRUCTION OF THE BUNSEN BURNER.

Unscrew the tube, examine and light the inner jet. Examine the outer tube and collar that controls the air-ports. Turn off the gas and replace the tube. Now turn on the gas again, strike a match and approach it to the top of the tube. Always observe this latter precaution when lighting the Bunsen burner. Observe the character and color of the flame, move the collar on the tube and note the effect. Hold a piece of glass tubing near the top of the flame, remove from the flame and bend. Hold it in the same position in the yellow flame, and after removal observe the condition of the tube and try to bend it. Is there any apparent difference in the intensity of the heat developed? Lower a piece of fine iron wire gauze half way in the flame, why does the flame fail to penetrate the gauze? Apply a light above the gauze, explain the phenomena. Place a piece of paper on the gauze, lower it half way in the flame, notice the charred ring. Hold a splinter at the same point in the flame, note where it is charred and explain. Introduce the large end of a dropping tube into the flame near the tube, and approach a light near the exit. From the results of the last three experiments what is your idea of the combustion zone?

Carefully turn the gas down at the key, watch the effect, why does the flame disappear? Now immediately turn the gas on full force and note the result. Approach a light to the upper end of the tube, observe the character of the flame, compare with the original flame

as to color and heating effect. Strike the rubber tube a quick blow with the closed hand and explain the resulting phenomenon.

Make a simple drawing illustrating the structure of the Bunsen burner, with the gas and air supply and the zones of combustion of the flame.

INSTRUCTION FOR MANIPULATING GLASS TUBING AND CONSTRUCTING SIMPLE APPARATUS.

Two kinds of glass, "hard" and "soft," are used in making apparatus for the laboratory. Hard glass is very brittle and quite infusible in the ordinary Bunsen flame. It is used in heavy apparatus where a high temperature is required for heating dry, but never liquid, substances, as the latter would cause it to break. It can usually be recognized by the striations on its surface and by its greenish-yellow color, best seen at the end of a broken tube.

Soft glass is less brittle than the other variety, is easily fusible in the Bunsen flame and is used in the construction of thin apparatus (such as beakers, test-tubes, etc.) for heating liquid, but never dry, substances.

The tubing used by the student for bending, blowing and fitting up apparatus should be of soft glass.

Cutting the Tube.—Glass tube up to one-fourth inch in diameter may readily be cut by making a slight scratch with a triangular file at the point of fracture, the tube is now grasped firmly in both hands holding the scratch outward and the thumb nails pressed against the

inner side of the tube opposite the mark, give a slight bend outward, at the same time pulling apart; the tube will make a clean break and no injury will be received. Broken in this way the tube ends are sharp and should always be rounded by heating for a moment in the flame.

Bending the Tube.—Take care that the tube is perfectly clean and dry inside and outside before heating. Adjust the wing-top to the burner and after lighting, heat the tube lengthwise in the upper part of the flame. Revolve the tube so as to heat all parts equally; when soft, remove from the flame and quietly bend to the desired angle. In case no wing-top is available, the tube may be heated in the same way in an ordinary illuminating burner. The carbon deposited on the tube is readily removed, after cooling, by rubbing with filter-paper.

Drawing the Tube.—Heat as before in wing-top or illuminating burner; when soft, remove from the flame and quietly but steadily draw apart. On cooling, the tube may be cut with a file at any spot, and will furnish two pointed tubes. These are used for dropping tubes, by cutting to the desired length and rounding the ends in the flame.

Closing the Tube and Blowing Small Bulbs.—Select a tube with thick walls, cut off a piece about a foot long, heat the square-cut end in the upper part of the ordinary Bunsen flame, revolving the tube continuously while heating; in a short time the tube will close. To blow a

bulb continue the heat for a few minutes longer, then remove and blow quietly but strongly into the open end of the tube, continue the air pressure until the desired diameter has been reached, but on no account attempt to make a bulb of more than double the diameter of the original tube, as in this case the walls will be too thin. If it has been impossible to blow a bulb of the desired size in one operation, the tube may be reheated and blown again until the desired diameter has been reached.

Glass rod may be cut, bent and rounded in manner similar to tubing.

CONSTRUCTION AND USE OF THE WASH-BOTTLE.

Select a clean eight-ounce wide-mouthed bottle, fit to it a rubber stopper pierced with two holes. Now cut two pieces of one-fourth-inch glass tubing, six and ten inches long, heat the longer piece in the wing-top flame about three inches from the end, when soft remove from the burner and bend to an angle of 45°. Heat and bend the shorter piece in the middle to an angle of 135°, round both ends of each tube in the flame, when cold moisten one end of the short tube with saliva and push it through one hole of the stopper, proceed in the same way with the longer tube but push it nearly up to the bend, so that when the stopper is inserted in the bottle the other end will just clear the bottom. Cut a piece of black rubber tubing two inches long, slip one end over the longer tube, make a jet by cutting off two inches of the pointed end of a dropping tube, round the rough end,

and when cool push it into the rubber tube. The bottle is complete and ready for filling with cold water. By blowing into the short tube, a fine jet of water will issue from the nozzle; by tipping the bottle upside down, a larger stream will issue from the shorter tube.

Wash-bottles for hot liquids are made in the same way, using a thin glass flask instead of a bottle.

CARBON AND COMBUSTION.

Wood contains moisture (H_2O), resin (C_xH_x), starch and cellulose ($C_6H_{10}O_5$), oil ($C_xH_xO_x$), mineral matter or ash.

Considerable heat is required to drive off the moisture and raise the starch, cellulose, etc., to such temperatures that they will decompose, yielding gases of a combustible nature; for example, CO, CH_4, C_2H_4, C_2H_2, H_2; in this decomposition H_2O is formed and must be driven off as a gas, much heat is also absorbed by the ash in forming new chemical compounds. In fact the fuel efficiency of wood depends entirely upon the relative volumes of combustible gas and charcoal furnished, and as the charcoal or carbon is the best solid fuel, the wood furnishing the largest proportion of carbon in this form is the best fuel, hence we find it advantageous to use hard wood. It must be understood that carbon or charcoal at a red heat combines with a limited amount of oxygen and forms a combustible gas, carbon monoxide, CO, a fuel of the highest heating efficiency.

Coal is superior to wood as it contains less water and

produces less by chemical change and yields the combustible gases and carbon (coke) in larger proportion. Hard coal is superior to soft, since it is a purer form of carbon and yields no combustible gas. Gas is superior to any solid fuel, as it has no water to vaporize and no ash. Gas containing CH_4, C_2H_4, and C_2H_2 is called illuminating gas and does not produce the heating effect of fuel gas composed of H_2 and CO. Even when both are used in the Bunsen burner, a glance will show that one will produce a large amount of H_2O by combustion, while the other does not, and as water absorbs much heat, that producing the least amount will absorb the least heat. The reactions taking place will be given under the Bunsen and common burners.

Destructive Distillation.—Make a capillary tube as directed, and insert it in a perforated cork. Now place in a hard glass test-tube small pieces of hard wood, insert the cork and clamp the tube and contents in a slightly inverted and inclined position on the ring-stand. Gently heat the tube in the flame, from mouth upward. From time to time try the exit tube with litmus paper, and then with the flame, continue the heating until the pieces of wood appear to be completely charred, but avoid burning the cork. Before allowing the tube to cool, carefully remove the cork, collect any liquid in the tube in a small dish, and close with a fresh cork. Observe the odor and general character of the liquid and test with litmus paper. When the tube is cool remove the charred material, carefully observe its character with

a magnifying glass, and make a rough sketch of its structure, float a small piece on water, and boil it for ten minutes, try another piece in the flame, burn another piece in a porcelain dish. Is there any residue? If so, note its character.

Repeat the same experiment using bituminous, and anthracite coal. Note any difference in the products of distillation of soft coal and wood.

Arrange the results of these experiments in tabular form.

Behavior of Mixtures of Gas and Air.—Fill a 250 cc. wide-mouthed bottle with about four-fifths air and one-fifth gas, collecting it over water, cover with a glass plate and shake thoroughly. Quickly replace the glass plate with wet filter-paper, pierce with a pencil point, apply the flame and note the result. Try the same experiment, using gas alone.

Products of Combustion.—Hold a clean dry flask filled with cold water over a Bunsen flame and note the result. What compound is formed? Explain.

Substitute a pointed glass tube for the Bunsen burner, turn the gas low and light at the point, introduce the flame into a clean dry bottle and hold it there for a few moments, note the result and remove the tube. Again introduce it under the same conditions and note the result. Remove the tube, cover the bottle with a glass plate and turn off the gas. Pour about 10 cc. of lime-water into the bottle, shake well, note the result, explain and write the equation.

The common burner can use gas of only the following composition, *i. e.*, methane, CH_4, ethylene, C_2H_4, acetylene, C_2H_2, hydrogen, H_2, carbon monoxide, CO, and combustion proceeds according to the following equations :

$CH_4 + 2O_2 = CO_2 + 2H_2O$ heat, no light.
$2H_2 + O_2 = H_2O$ " " "
$2CO + O_2 = 2CO_2$ " " "
$C_2H_4 + O_2 = 2H_2O + C_2$ less heat, some light.
$2C_2H_2 + O_2 = 2H_2O + 2C_2$ " " more "

The Bunsen burner mixes the gas with O_2 before combustion; this change affects only the ethylene and acetylene, as follows :

$C_2H_4 + 3O_2 = 2H_2O + 2CO_2$ heat, no light.
$2C_2H_2 + 5O_2 = 2H_2O + 4CO_2$ " " "

ASH OF COAL OR WOOD.

Wood Ash.—Burn a small piece of hard wood or charcoal on platinum foil until thoroughly ashed, cool and transfer to a small porcelain dish, add a small quantity (5 cc.) of distilled water, and heat to boiling. Is there any residue? If so, note its character. Filter, if necessary, and test the filtrate with red and blue litmus paper, dip a clean platinum wire in the solution and then heat it in the Bunsen flame; observe the color with and without blue glass.

Coal Ash.—Burn a portion of pulverized coal on platinum foil until completely ashed (this may take some time during which other experiments may be

proceeded with). Cool and treat the ash with 5 cc. of distilled water, filter, test the filtrate as above, treat the residue with warm, dilute hydrochloric acid (HCl), note the character and amount of residue from the latter treatment. Test a portion of the hydrochloric acid solution in a test-tube as follows :

1. For lime (CaO). By adding ammonium hydroxide (NH_4OH) until alkaline, and then an equal bulk of ammonium oxalate, and heat to boiling; a white crystalline precipitate indicates lime.

2. For iron (Fe_2O_3). Test the remainder of the solution for iron, by adding to the test-tube of liquid a few drops of ammonium thiocyanate (NH_4SCN); a red color indicates iron.

A more elaborate method for analysis of ash is given on page 11.

LIQUID FUELS.

Note.—On account of the highly inflammable nature of the following compounds very small amounts must be taken for tests, and particular care exercised with the use of the naked flame.

Naphtha and Gasoline.—Pour not more than one or two drops of the liquid into a clean dry eight-ounce bottle, stir the vapor with a hot glass rod, withdraw the rod and apply a light, note the result.

Pour the same quantity of liquid into a shallow porcelain dish and immediately apply a flame, note the result and explain the difference in the two phenomena.

Pour 20 drops of the liquid into a flat watch-glass, allow it to stand and note the time of evaporation and the quantity of the residue, if any. (Test for the presence of water.)

Gasoline or naphtha should be neutral; try it with delicate litmus paper.

Kerosene.—Gently heat a small cup half full of the oil over hot water, and note the temperature at which inflammable vapor is given off; this is called the flash-point and is a valuable indication of the quality of the oil. Try the reaction with litmus paper. This compound is called an oil; heat a little with strong caustic lye; does it make soap?

Paraffin.—Heat a small lump of paraffin in a clean, dry porcelain dish over a low Bunsen flame and note the flash-point as before. Heat a portion with caustic lye; does it saponify? Compare and explain the difference in inflammability of gas, kerosene and paraffin.

Make mixtures of small portions of clean tallow or lard with cold gasoline and kerosene and with heated paraffin; filter the liquids if not clear and carefully evaporate small portions of each on the water-bath. Compare the residues with the original substances. Explain the action of these solvents in removing grease spots.

Make mixtures of equal quantities of gasoline and cold water, kerosene and cold water, and melted paraffin and warm water in small corked test-tubes, shake well

and observe their condition. Now allow the tubes to rest quietly for ten to fifteen minutes then carefully open each and note the condition and position of each. Try the specific gravity of kerosene and naphtha with the hydrometer.

WATER.

Physical Properties.—1. Pour 250 cc. of water into a small round-bottomed flask, introduce a thermometer so that the bulb is immersed in the liquid and apply heat. Note the point at which the thermometer rises when the liquid boils quietly. Raise the thermometer just out of the liquid. Is there any change? Does the thermometer indicate any higher degree of heat when the water is boiling violently?

2. Repeat the experiment after dissolving a tablespoonful of salt in the water, and note the point at which the liquid now boils. Save this liquid for future use. (Expts. 7 and 13).

3. Note the boiling-point of a mixture of equal volumes of water and alcohol.

4. Select a cork which fits the flask, pierce a hole through it sufficiently large for a thermometer, and half fill the flask with pure water. Boil the liquid and when it is in active ebullition, close the flask with the cork fitted with the thermometer and withdraw the heat. In a few minutes the liquid will cease to boil. Watch the thermometer. Pour cold water on the outside of the flask until boiling is resumed and watch the thermometer. Explain the result.

5. Place a fresh egg in cold distilled water and note how much salt must be dissolved in it before the egg floats. Explain this phenomenon.

6. Heat a flask containing about 250 cc. of fresh cold tap water over the double boiler or water-bath. Observe the air bubbles which collect on the sides of the vessel and also the highest temperature of the water obtained by this method.

7. Take a portion of salt solution prepared in Experiment 2 and boil it down to one-half of its original bulk in a small beaker; note with a thermometer the point at which it boils, and make frequent readings of the thermometer until the desired bulk is reached, then remove the thermometer and allow the liquid to cool thoroughly; examine the result with a lens and draw what you see. Taste it; does it suggest the original salt?

8. Make a strong solution of cane-sugar in water, treat it in the same way as the salt solution, and record your results.

9. Take half a teaspoonful of dry pulverized lime (CaO), add to it a teaspoonful of cold water, stir the mixture in a porcelain dish with a thermometer, adding more water if necessary, record the thermometer readings carefully, at the conclusion of the experiment, wash the material into a wide-mouthed bottle, fill up with distilled water, cork and shake well, let stand until clear and then carefully pour away the liquid, add more water, cork and shake well again, reserve for future use. The second

clear solution is called lime-water, ($Ca(OH)_2$), and is much used in the laboratory and household as a mild alkali; try it with litmus paper, also taste the clear liquid.

10. Take a tablespoonful of common plaster, mix with half the volume of water, in a porcelain dish, stirring as before with a thermometer. Read the thermometer as the mass hardens. Record the result and compare with Experiment 9.

11. Slowly pour about 10 cc. of strong sulphuric acid (H_2SO_4) into 50 cc. of cold water, stir well with a thermometer and from time to time record the temperature.

12. Carefully mix exactly nine volumes of alcohol (C_2H_5OH) and one volume of water; how many volumes result? Record and explain.

13. Add two or three drops of the liquid from Experiment 2 to 100 cc. of water and filter; is any change produced? Now add to the filtrate a few drops of silver nitrate ($AgNO_3$) shake well and filter again; note any difference.

14. In eight ounces of water dissolve enough copper sulphate to give the resulting liquid a distinct but not deep shade. Filter a little of this; what is the result? Reserve the bulk for Experiment 15. What inferences do you draw from Experiments 13 and 14?

15. Distillation of water.

A. Place on a wire gauze or sand-bath and make firm with a clamp, a round-bottomed half-liter flask containing about 250 cc. of the liquid made in the preceding experiment. Insert in the flask a cork fitted with a

thermometer and a 45° exit tube and connect this latter with a straight tube air condenser. Begin the distillation, taking note of the boiling-point of the liquid. Examine carefully the distillate, and see if you can detect any trace of copper sulphate. Also test with phenolphthalein.

B. Cool the apparatus and add ammonia to the liquid in the flask until a clear, deep blue solution is obtained, cork and distil again, testing as before. Note the difference of behavior of the volatile and non-volatile compounds.

Instructions for Making a Simple Filter and Operating the Same.—Take a clean colander, lay in it a piece of well-boiled muslin and cover with a layer of clean boiled sea-sand one to one and a half inches deep. Filter the sample of boiled water through this; if once is not enough, repeat.

Some waters are stained brown or yellow by vegetable matter and contain finely divided clay; in either case add a small quantity of alum (point of the small blade of a pen-knife) to the gallon of water, heat slowly to boiling, and then filter.

The muslin and sand may be used many times, but before each operation should be treated as follows: Scald the cloth and heat the dried sand at least thirty minutes in a hot oven.

Qualitative Examination of Water.—No attempt will be made to give methods for quantitative analysis of

the impurities found in water, but certain qualitative tests which will aid in detecting such impurities, when present in abnormal amounts, and it is only when found in abnormal amounts that the water is open to suspicion. The impurities are for the most part harmless in themselves, and a thorough investigation of the surroundings and sources of contamination of the water supply, care in taking the sample, and other precautions are quite essential.

The tests usually made are: Color and appearance, odor and taste, and for the presence of total solids, free and albuminoid ammonia, nitrogen as nitrites and nitrates, chlorine, temporary and permanent hardness, and sometimes phosphates, sulphates, etc.

Total Solids.—Evaporate to dryness in a clean porcelain dish 100 cc. (about three ounces) of ordinary drinking-water. Examine the residue if any, and notice if it blackens on heating. This indicates organic matter.

Phosphates may be determined at this point by adding to the residue a little water, nitric acid and ammonium molybdate. If phosphates are present, a yellow crystalline precipitate will be formed on heating to body temperature.

Ammonia.—Two forms of ammonia are looked for in water, the "free ammonia" and the so-called "albuminoid ammonia."

Free Ammonia.—This is determined by distillation as in Experiment 15, omitting the copper sulphate and ammonia, and testing each 20 cc. of the distillate with

Nessler's solution which gives a yellow or brown color in the presence of ammonia. Continue until a portion is found which fails to respond to the test; at this point the water is ammonia-free.

Albuminoid Ammonia.—This is ammonia derived from organic matter, by means of alkaline permanganate of potassium. It may be applied to the water already in the flask from which the free ammonia has been expelled, or to a fresh sample, in which case you obtain the total ammonia and deduct the free ammonia.

Test.—In either case, add to the water in the distillation flask 10 or 15 cc. of alkaline permanganate, boil and test the distillates as before with Nessler's solution. Note the difference in the amount of ammonia set free.

Nitrites.—The presence of nitrites in water is supposed to be due either to the reduction of nitrates already present in the water by the action of organic matter, or to the oxidation of organic nitrogen to nitrite.

Test.—To about 25 cc. of water in a large test-tube, add 5 cc. of freshly prepared mixture of equal parts of sulphanilic acid dissolved in acetic acid, and of naphthylamine acetate dissolved in dilute acetic acid, mix and allow to stand for about thirty minutes. If the solution becomes pink, the water contains nitrites. Compare with a sample of water known to be nitrite-free.

Chlorine.—Chlorine is found mostly as sodium chloride, although other chlorides may be present.

Test.—Place in a small casserole or porcelain dish

about 100 cc. of tap water, and in another dish the same amount of distilled water. Add to each, two or three drops of potassium chromate solution, then add, drop by drop, a dilute solution of silver nitrate, (N/10) stirring after the addition of each drop, until a faint tinge of red appears in the liquid. Obtain the same tint in each and note the number of drops of silver nitrate used in each case. The difference between the two shows the amount of chlorides present. Each drop of silver nitrate solution is equivalent to 0.00279 gram of sodium chloride.

Hardness.—By hardness is meant the soap-destroying capacity of a water. This property is due principally to the fact that calcium and magnesium salts form, with ordinary soaps, insoluble compounds or soaps which separate as a curd in the water and have no detergent value. The hardness of a water may be classified under two heads, *viz.*, "Temporary" and "Permanent."

Temporary Hardness.—Temporary hardness is caused by the carbonates of calcium and magnesium held in solution by carbonic acid present in the water. Boiling expels the carbon dioxide, causing the precipitation of calcium and magnesium carbonates.

Dilute 10 cc. of clear lime-water to 50 cc., place the mixture in a large test-tube and pass a rapid current of carbon dioxide (made from marble and dilute nitric acid) through the liquid. Carefully observe the changes in the liquid and when perfectly clear stop the passage of

the gas. Now transfer the liquid to a small low flask fitted with stopper and double bent glass tube, the longer leg of which should project into a test-tube of lime-water. Boil the contents of the flask violently for some minutes, but keep the lime-water cool. Carefully note and explain all changes in the contents of flask and tube. Finally cool the flask and filter off the clear liquid, pass carbon dioxide through this as before, and explain the difference in behavior.

Note the condition of the walls of the flask; why will not water remove the crust? Try dilute acid and watch its action. What is the crust?

Test.—Place 100 cc. of tap water in an eight-ounce bottle and add a solution of pure castile soap (10 grams dissolved in dilute alcohol), 0.5 cc. at a time, shaking thoroughly after each addition, until a lather is formed which lasts five minutes. Note the amount of soap solution used.

Now boil 100 cc. of the same sample and repeat the test, noting again the amount of soap solution used. The difference gives the temporary hardness.

Permanent Hardness.—Permanent hardness is caused by the presence of calcium sulphate and other soluble salts of calcium and magnesium, not carbonates, held in solution by the solvent action of the water itself; such a water cannot be materially softened by boiling but may be softened by boiling with sodium carbonate, which converts the sulphates, etc., into carbonates and precipitates them as such.

Dissolve 0.1 gram of plaster (calcium sulphate) in 100 cc. of distilled water, pass a rapid current of carbon dioxide through the solution and continue at least as long as in the case of lime-water. Why is the action not the same? Finally add sodium carbonate solution and note the result. Explain.

Some waters possess both temporary and permanent hardness, in which case the total hardness is first determined; the water is then boiled and the permanent hardness determined and then the temporary hardness obtained by difference.

THE ATMOSPHERE.

Composition.—Pure air is mainly composed of four parts of nitrogen and one part of oxygen. Other constituents occur in small quantities, chief of which are water and carbon dioxide.

Oxygen is a colorless, odorless, tasteless gas, slightly soluble in water. It supports combustion, combines with all the elements except fluorine, during the operation heat and sometimes light is evolved. Oxygen supports life and maintains the animal heat by combining with the carbon and hydrogen of the food materials. It acts as the great disinfectant and deodorizer, destroying many bacteria.

Nitrogen is a colorless, odorless, tasteless gas, almost insoluble in water, does not support life or combustion, is non-poisonous, and does not cloud clear lime-water. It acts as a diluent of the atmospheric oxygen and to some extent as food for plant life.

Carbon dioxide is a heavy gas, colorless, tasteless, odorless, product of combustion of carbon, but does not support life or combustion; is non-poisonous, soluble in water, forming carbonic acid (a weak acid), and the solution clouds clear lime-water. It is the main food for plants, enabling them to produce starch with the aid of moisture and sunlight. $6CO_2 + 5H_2O = C_6H_{10}O_5 + 6O_2$.

The excess of oxygen is returned to the atmosphere. Part of the CO_2 dissolves in water and combines with CaO (lime) furnishing shells of mollusks and finally limestone, marble, chalk and various other useful carbonates.

H_2O is a colorless, odorless, tasteless liquid at ordinary temperature, solid at 32° F., gas at 212° F., volatile at all temperatures, without change of composition, is a universal solvent, food, does not mix with ordinary fats and is more dense. Wood floats in it, metals do not. Iron rusts in contact with water. It is neutral, *i. e.*, neither acid nor alkaline.

Oxygen and nitrogen have nearly the same density and are mechanically mixed in air, the mixture is maintained by constant movement (wind currents). Oxygen withdrawn by animals and combustion is replaced by plants, some carbon dioxide is withdrawn by rain, which washes out other impurities. Excess of moisture is removed by fall of temperature, in the form of rain, hail, snow, and dew.

Oxygen, O_2.—Pour one inch of alkaline pyrogallol into a short, broad test-tube, close with a rubber stopper, invert and mark the position of the stopper and liquid on a

gum label pasted on the outside of the tube; now shake the tube well, invert and open under water, mark the level of the water in the tube when open, and explain the phenomena.

Carbon Dioxide, CO_2, and Nitrogen, N_2.—Fasten one inch of Christmas candle to a flat cork, float on a shallow dish of lime-water, light the candle and invert a clean dry beaker over it; add more lime-water if necessary. Describe and explain the result. Try a lighted candle in the residual gas; what is the result? Explain.

Carbon Dioxide, CO_2.—Expose a few drops of lime-water on a slide to the air and notice that by the end of the lesson it is cloudy. Examine under the microscope the rhombohedral crystals of calcium carbonate ($CaCO_3$) and draw a diagram of them.

Hydrogen Sulphide, H_2S.—Moisten a filter-paper with a solution of acetate of lead and expose to the air until the end of the lesson. Notice the black coloration due to the formation of lead sulphide. This test works very well in gas-lit rooms.

Moisture.—(1) Expose a strip of dry cobalt chloride or cobalt iodide paper to the air and at the end of the lesson note the change in color.

(2) Expose a little calcium chloride ($CaCl_2$) on a watch-glass, let it remain until the next lesson and note any change.

Dust and Solid Matter.—Put a drop of glycerin on a

slide, place it outside the window and examine under the microscope at the next lesson.

Ferments.—Expose about a teaspoonful of weak sugar solution in a test-tube for about one hour, then loosely plug with cotton and examine it at the next lesson as to taste, odor and appearance. Place a drop on a slide and examine under the microscope.

Food Principles consist of carbohydrates, fats, proteids and mineral matter.

Carbohydrates.—Compounds containing C, H and O, the H and the O in the proportion of 2 : 1 and the C 6 or some multiple. Examples of these compounds are starch, cellulose, glucose, sugar, etc.

Composition of Carbohydrates.—White sugar is used since it is the purest commercial carbohydrate.

1. *Determination of Hydrogen and Oxygen Evolved as Water.*—Heat about 1 gram of granulated sugar in a clean dry test-tube. Observe the condensation of moisture in the cooler part of the tube.

2. *Determination of Carbon.*—(*a*) By direct heat, continue heating and note the blackening of the mass due to freeing of some of the carbon. (*b*) By dehydration, treat about 1 gram of the sugar in a porcelain evaporating dish with a little concentrated sulphuric acid, heat gently and note the blackening effect. In this case the concentrated sulphuric acid withdraws the hydrogen and oxygen in the form of water and leaves the carbon.

3. *Determination of Hydrogen and Oxygen in the Form of Hydrocarbons, i.e., Tarry Bodies.*—Observe the pungent odor of the vapors arising from the tube during the heating in Experiment 2, (*a*). This usually condenses on the cooler part of the tube in the form of a dark brown liquid (caramel).

(STARCH, $C_6H_{10}O_5)_n$.

Ordinary Starch Derived from Potatoes or Corn.—1. Examine a thin section of potato under the microscope. Make a careful drawing of the structure of the cells and the granules within. Cover the section with a thin glass and introduce a minute trace of iodine solution at the edge of the cover glass. Note, and make a colored (blue pencil) diagram of the result.

2. Clean and peel one end of a small potato, rub it on an ordinary grater, collect the gratings in a beaker of cold water, allow the whole to stand for some minutes and examine the sediment.

3. Gently heat half an inch of dry starch in a clean, dry, six-inch test-tube, observe and explain the condensed moisture in the cooler part of the tube. Increase the heat somewhat and note the odor of the evolved vapor and the color of the starch; what does it suggest? Now heat strongly until only a black residue remains; what is it?

4. To a small portion of dry starch in a porcelain evaporating dish add a few drops of concentrated

sulphuric acid; note the result and after a short time heat gently and observe again.

5. Treat a small portion of finely pulverized dry starch with cold water, filter a portion and examine the filtrate for dissolved material, by evaporating a little on platinum foil; also by the iodine test.

6. Boil the remainder of the starch and water mixture; it gelatinizes. Filter some of this and test the clear, cold filtrate with iodine, explain. To the remainder when cool add a minute portion of iodine solution; it is colored blue. Gently heat this and allow to cool again; note the result. Now boil for some time, cool, the color does not return. Examine under the microscope portions of raw and cooked starch, with and without iodine.

7. To some starch solution in a test-tube add a small portion of caustic soda solution (NaOH) and a few drops of iodine solution and note the result. Repeat the experiment using dilute sulphuric acid instead of NaOH.

8. Add a solution of tannic acid to some starch solution. Note the result, also any change effected by heating.

9. **Starch, a Colloidal Substance.**—Prepare a dialyzer as directed and partly fill it with starch solution, then stand the whole in a beaker of cold water. After standing for some time test the water for starch with iodine solution.

10. Make a very weak solution of starch in about eight ounces of boiling water ; to half of this solution add

20 drops of strong hydrochloric acid and boil until clear, replacing the water lost by evaporation. At this point a small quantity of the cooled solution should give no blue coloration with iodine solution. If this is not the case add 10 drops of the same acid and boil some minutes longer, or until a small portion gives no test with iodine as above. Now neutralize the remainder of the solution with sodium carbonate solution. Prepare a Fehling solution by mixing 5 cc. of copper sulphate and 5 cc. of alkaline Rochelle salt with 20 cc. of distilled water and boil the solution exactly two minutes. During this period no change should take place in the liquid. Now add 1 or 2 cc. of the neutralized starch solution and boil again for two minutes. Note the change in color of the liquid and, when cool, the red precipitate of cuprous oxide, indicating the presence of a reducing sugar, *i. e.*, glucose. If the changes indicated do not take place, add more solution and boil again.

11. Test the remaining half of the solution in experiment 10 directly with Fehling's solution.

12. Test with unorganized ferments: ptyalin from saliva and diastase from malt. Prepare saliva in the following way: rinse out the mouth with water, curve the tongue so as to place its tip behind the upper incisor teeth, then inhale the vapor of ether or even cold air; collect the saliva in a small test-tube, dilute with five times its volume of water and filter through a filter perforated with the point of a pin.

Make a starch solution in water, add a few cubic

centimeters of saliva, warm (not above 40° C.) until clear, cool and test with (*a*) iodine solution, and (*b*) Fehling's solution (maltose).

To a weak starch solution add about 5 cc. of diastase solution and heat to 60° C. As soon as the paste becomes clear test a portion with iodine solution and continue testing portions until the test fails to give a color (maltose). At this stage boil the remainder of the solution with about 25 drops of dilute sulphuric acid for about ten minutes. Test this with Fehling's solution (dextrose).

DEXTRINE — Erythrodextrine, Achroodextrine, Maltodextrine } $C_6H_{10}O_5$.

Dextrine or "British Gum" is prepared commercially by heating starch moistened with nitric acid. It may be prepared more conveniently by heating strong starch paste with moderately dilute sulphuric acid, cooling and precipitating the dextrine by adding alcohol.

Try the solubility of dextrine in cold and in boiling water. To successive portions of cold dextrine solution in test-tubes add:

1. Iodine solution.
2. Alcohol.
3. Caustic potash and iodine solutions.
4. Sulphuric acid and iodine solutions.
5. To still another portion add a few drops of ammonia and basic acetate of lead; note the result. This is the characteristic reaction for gums.

6. Test some dextrine solution with Fehling's solution; if pure, there will be no reduction.

7. Test with tannic acid as under starch.

8. Take about 25 cc. of clear dilute starch solution in a small beaker and add 2 or 3 cc. of undiluted saliva, keep at body temperature and from time to time filter off small portions and test with iodine solution, keeping each for comparison. Note the gradual change from blue to red to yellow and finally colorless. The stages are: Starch, blue; erythrodextrine, red; achroodextrine, yellow; maltodextrine, colorless.

GLUCOSE--$C_6H_{12}O_6$, (Dextrose, Levulose, etc.).

Note the taste and solubility in hot and cold water, also the reaction towards iodine solution as with dextrine.

1. Heat some dry glucose in a clean, dry test-tube; note the result and compare with starch and sugar.

2. To some dry glucose in a porcelain dish add cold concentrated sulphuric acid; note the result. After allowing the test to stand for five minutes, heat gently and note the result. Compare with sugar.

3. Make a syrupy solution of glucose (dextrose) and allow it to stand for several days. Do any crystals form? Compare with sugar (Expt. 11, p. 33).

4. Rub up some glucose solution with compressed yeast in a porcelain mortar and pour the mixture into a short, broad test-tube until full of the liquid. Close the test-tube with a perforated cork bearing a glass tube bent

in the form of the letter J, having the shorter end projecting through the cork, and the longer reaching to the level of the bottom of the test-tube. This J-tube should also be filled with the liquid. Care should be taken that there is no air in either tube. Now invert the apparatus and let it stand quietly in a warm place for twenty-four hours, note the result, explain the collection of bubbles or space above the liquid, and hold a drop of clear lime-water on a rod over the open tube: why does the drop turn milky? Examine the liquid for alcohol by taste and odor and by heating with a few drops of iodine solution and caustic potash—odor of iodoform.

5. To some glucose solution add strong caustic potash and heat; note the result.

6. To 15 or 20 cc. of ammoniacal silver nitrate solution (prepared by adding ammonia cautiously to silver nitrate until the brown precipitate has almost disappeared; if carried too far add a little dilute nitric acid until the brown precipitate just reappears) in a clean test-tube, add a few drops of glucose solution and caustic potash, heat gently and note the result.

7. **Fehling's Solution Test.**—In a 100 cc. flask take 5 cc. of copper sulphate solution and 5 cc. of alkaline Rochelle salt, mix and add 20 cc. of distilled water, and a few pieces of pumice stone (to prevent bumping), and boil for two minutes (during this time no change should take place). Now cautiously add a little glucose solution, boil vigorously for two minutes, cool and note the result. Continue adding glucose and boiling until on cooling a

decided change has taken place in the color of the solution and a red precipitate is formed. Compare with Experiment 10 under starch.

8. Test some glucose with Nylander's solution, note the result.

9. Test some weak glucose solution with Barfoed's reagent; do not boil.

10. To 5 cc. of dextrose solution in a test-tube add 0.1 gram of phenyl hydrazine hydrochloride and 0.2 gram of sodium acetate (or equal volumes of the two reagents may be used), heat the mixture gently until all solids dissolve, then keep it in boiling water for fifteen to twenty minutes, cool and examine the yellow radiating needles of phenyl glucosazone. Compare with lactose and maltose.

SUGAR—$C_{12}H_{22}O_{11}$.

1. Examine the crystalline structure of granulated sugar.

2. Roughly determine its solubility in cold water. Is the solubility affected by heat?

3. Boil down sugar solution to dryness and note the result.

4. Drop some concentrated sulphuric acid on dry sugar, note the result and compare with starch and glucose.

5. Add a saturated sugar solution to 95 per cent. alcohol and note the result.

6. Boil some sugar solution with Fehling's solution. If pure, there should be no reduction.

7. Boil some sugar solution with a few drops of concentrated hydrochloric acid, cool, neutralize with sodium carbonate and again test with Fehling's solution; note the result and compare with glucose. What change has taken place in the sugar?

8. Test sugar solution with Nylander's solution, before and after boiling with acid.

9. Repeat test with Barfoed's solution as in Experiment 9 under glucose.

10. To 10 cc. of sugar solution add some strong caustic potash, heat and note the result; compare with glucose.

11. Make a hot syrupy solution of sugar and suspend in it a piece of glass rod by thread, place aside and allow to cool and after a time carefully examine the crystals of cane-sugar.

12. **Test for Sucrose.**—To 15 cc. of the clear liquid add 5 cc. of cobalt nitrate (5 per cent.), and 2 cc. of caustic soda (50 per cent.). *Sucrose* gives an amethyst-violet, permanent on heating. *Dextrose* gives turquoise-blue, turning to green on heating. This test may be used on milk, honey, preserves, etc. To remove gum or dextrine, add ammonia and basic acetate of lead, filter and test the filtrate.

Additional Tests on Sugar.—Boil a strong solution of sugar until it has turned brown (caramel), cool, dilute, and test some of the liquid with Fehling's solution. Filter the balance through bone-black and note the loss of color; it may be necessary to pass the liquid through the same filter several times.

Viscogen.—To prepare viscogen for restoring the consistency of pasteurized cream : Two and a half parts by weight of a good quality of granulated sugar are dissolved in five parts of water, and one part of quicklime gradually slaked in three parts of water. The resulting milk of lime is strained and added to the sugar solution. The mixture should be agitated at frequent intervals, and after two or three hours allowed to settle until the clear liquid can be decanted off. This clear liquid (viscogen) is the part used and should be kept in well-stoppered bottles, as it loses strength and becomes dark-colored when exposed to the air. The darkening in color, however, does not impair its usefulness.

CELLULOSE—$(C_6H_{10}O_5)_n$.

This compound forms the skeleton and covering of the plant in the shape of a fine network of interlacing fibers. Cellulose is characterized by its extreme insolubility, being unacted upon by dilute acids and alkalies. Concentrated sulphuric acid slowly turns paper, a representative of cellulose, into hydrocellulose or parchment; extremely concentrated caustic potash acts in a similar manner. Highly concentrated nitric acid converts cellulose into a nitro-compound known as guncotton, which is soluble in ether alcohol and known as collodion. The cellulose is quite readily dissolved by warming with "Schweitzer's reagent," which consists of copper oxide dissolved in ammonia, or by a strong solution of zinc chloride. Cellulose may be reprecipitated from these

solutions by adding very dilute acetic acid. Cellulose is not colored by the action of iodine solution unless previously treated with strong sulphuric acid.

Various Forms of Cellulose.—Cotton. Cotton occurs in flat ribbon-like fibers, easy of detection under the microscope. Examine and draw diagrams of various samples of cotton fiber and then stain the fiber with diluted iodine solution. Try the solubility of cotton in cold concentrated sulphuric acid, afterward dilute with water and add iodine solution.

Paper.—Examine two or three samples of paper under the microscope. It is best to use ashless paper, ordinary filter-paper and writing paper. Try the iodine test on each one of the samples, and note the result. Try the solution of small particles of cotton and chemically pure paper in warm Schweitzer's reagent, and in saturated zinc chloride.

Crude Fiber.—Cellulose in the form of crude fiber, occurring in various forms of plants, remains as an insoluble residue after removal of the starch, proteids, fats, etc., by successive treatments of hot solutions of sulphuric acid and caustic potash, followed by water, alcohol, and ether in the order named. Conduct the experiment as follows :

Take 3 grams of dry meal or flour, treat with 200 cc. of warm 1.25 per cent. sulphuric acid for half an hour. Allow the precipitate to settle, and decant or siphon off the clear liquid. Treat once or twice with the same bulk of water, removing the liquid as before. This operation

is to remove starch, dextrine and other saccharides. Now treat the residue with 1.25 per cent. caustic potash, same as in the acid solution. Wash once or twice with warm water, then with alcohol, then with ether. The residue is crude cellulose. The caustic potash has for its office the removal of the fat and proteids. The alcohol and ether remove the last traces of water.

Experiments on Nitrocellulose or Guncotton.—

1. Examine with lens or under microscope.

2. Compare the combustibility of nitrocellulose and ordinary cotton.

3. Dissolve some guncotton in a mixture of ether and alcohol. Pour some of the clear liquid (collodion) on a clean sheet of glass. When dry, peel off the coating and examine with lens.

MALTOSE—$C_{12}H_{22}O_{11}$.

Maltose does not occur in nature, but is produced during the hydrolysis of starch by unorganized ferments, such as diastase, ptylin, etc.

Preparation of Malt.—Malt is produced during the germination of barley and other cereals. Prepare it as follows: spread out a thin layer of barley grains (1 tablespoonful) on the cover of a small pasteboard box, moisten with warm water and keep in a moderately warm place. Each grain will soon begin to sprout. When the rootlet has grown the length of the grain dry in an oven at a low temperature and keep bottled.

Make malt extract by grinding the grains coarsely and extracting them with 100 cc. of warm water. Note the taste and odor of the liquid. Keep for future use.

Preparation of Maltose.—Make a thin starch paste with boiling water, cool to 60° and add 10 cc. of malt extract, prepared as above, and continue the heating at 60° C. for half an hour. From time to time test small portions of the liquid with iodine solution; when the liquid fails to react blue, cool the balance of the solution, divide in parts and test as follows :

1. Add some of the liquid to strong alcohol, allow it to stand, and note the white precipitate of dextrine ; the liquid contains maltose.

2. To 10 cc. of Fehling's solution add a few drops of the liquid, boil for two minutes and note the reduction; add more of the solution and boil again; repeat until the reduction is complete; compare with glucose.

3. Test with Barfoed's solution but do not boil.

4. Test with Nylander's solution, boiling as with Experiment 2.

5. Apply the fermentation test as under glucose, Experiment 4.

6. Test with strong caustic potash as under glucose, Experiment 5.

7. Repeat the phenyl hydrazine test as under glucose, Experiment 10.

LACTOSE.—$C_{12}H_{22}O_{11}$, H_2O.

1. Note its hardness and slightly sweet taste, due to limited solubility.

2. Try its solubility in water and alcohol.

3. Treat some dry powdered lactose with concentrated sulphuric acid; note the result.

4. Try the caustic potash reaction.

5. Apply Fehling's test.

6. Test with Barfoed's solution in the cold.

7. Test with Nylander's solution.

8. Make a weak solution of lactose in water, let it stand at least twenty-four hours in a moderately warm place, and then test for acid.

9. Make phenyl hydrazine test as under glucose.

GLYCOGEN.—$C_6H_{10}O_5$.

Grind up scallops with sand in a mortar, transfer to a beaker, add water enough to just cover the mass and boil. This dissolves the glycogen and partially precipitates the proteids, which are now completely precipitated by adding a few drops of acetic acid. Filter and to the filtrate add alcohol (95 per cent.) until glycogen comes down as a white precipitate. Allow to settle, decant off the clear liquid, and filter the remainder.

To portions of the solid glycogen left on the paper try the following tests :

1. Solubility in water, and look for opalescence.

2. Solubility in 10 per cent. sodium chloride solution.

3. Solubility in hydrochloric acid.

4. Solubility in caustic potash.

5. Iodine solution.

6. Boil in a beaker for fifteen minutes with 20 drops of

dilute hydrochloric acid, then neutralize with sodium carbonate and test with Fehling's solution. What change has taken place?

7. Glycogen is soluble in alcohol from 0 to 60 per cent. Glycogen is insoluble in alcohol from 60 to 100 per cent.

FATS.

There is much confusion in regard to the composition of the various bodies commonly known as fats. At least two distinct classes are recognized, *viz.*, (1) true fats or glycerides, containing carbon, hydrogen and oxygen, essentially in the form of fatty acid and glycerine, and existing as liquids and solids. (2) Hydrocarbons containing only carbon and hydrogen, in very simple forms of combination, but existing as gases, liquids and solids. The first always yield some of their carbon in the free state on heating, the latter rarely. Confirm this by burning small portions of tallow and of kerosene in separate porcelain dishes over the Bunsen burner.

Composition of Glycerides.—Determination of hydrogen and oxygen in the form of water. Boil 20 to 25 drops of clear olive oil in a clean dry, test-tube; note the deposition of moisture in the cooler part of the tube. Some of the water running back will cause the fat to crackle.

Determination of Glycerine, $C_3H_5(OH)_3$.—Continue the heating until dense fumes arise from the boiling liquid; this is due to acrolein, formed from the heated glycerine. Cool the tube and contents and reserve for the next step.

Determination of Carbon and Hydrogen as Hydrocarbons.—Pour the cold tube contents into a clean, dry porcelain dish and heat slowly but strongly over a low flame. Note the gradual darkening of the liquid due to freeing of some carbon and the tarry coat on the rim of the dish due to liquid hydrocarbons. Hold a lighted match over the dish and note the character of the inflammable vapor, due to gaseous hydrocarbons. Extinguish the flame and continue the heating until only a black residue remains; this is carbon; prove it by burning it off.

Preparation of Pure Fat from Natural Sources.—Weigh out 10 grams of beef suet cut up in small pieces. Place in a small evaporating dish and heat cautiously, stir with a thermometer and do not allow the temperature to rise above 130° C. (What causes the spattering?) When the spattering has ceased strain through muslin into a porcelain dish, squeeze out the cloth and reserve for tests on fats. Transfer the residue to a small mortar, add 5 cc. of strong alcohol, and grind well. Pour this mixture into a small flask, wash out the mortar with alcohol and add the washings to the flask, finally close the flask with a cork, bearing a condenser tube 24 inches long, support on a ring-stand over a water-bath and boil for ten minutes. When the suspended matter has settled, uncork the flask and pour the clear liquid on a small filter, allowing the filtrate to run into a large test-tube. To the residue in the flask add 20 cc. of ether, insert the cork and condenser and cautiously heat over

hot water for five minutes, then transfer the entire contents of the flask to a small muslin filter and collect the filtrate in the same tube as before. Wash this last residue with a little ether and squeeze out the ether, spread out on the muslin and allow it to dry and test the residue for proteid with Millon's reagent. Close the test-tube with a loose cotton plug and allow it to stand until crystals deposit from the liquid; examine these under the microscope and draw a diagram of them.

Make the following tests on the rendered fat:

1. Place a small piece of fat in a clean, dry test-tube, add 5 cc. of alcohol and heat until the fat melts, then test with delicate litmus paper.

2. Place a small piece of fat on a filter-paper and heat until the fat melts; note the result.

3. Rub up a small piece of fat in a mortar with some acid potassium sulphate, transfer to a clean, dry test-tube and heat cautiously; note the peculiar disagreeable odor of acrolein due to the dehydration of the glycerine. What does it suggest?

4. Warm a small piece of fat in a test-tube with strong sodium carbonate, shake well, noting the result and allow the mixture to stand. What happens?

5. *Saponification.*—Boil a portion of pure fat in a small flask with strong alcoholic potash solution. Replace the liquid lost by evaporation with hot water. As the evaporation proceeds, the mixture should become homogeneous. If it does not, add a little more potash and boil again but avoid any large excess. A drop of the hot

liquid should dissolve completely in hot water (soap). When saponified boil until the alcohol is removed, cool the liquid and divide into three portions.

A. To one portion add a rather strong solution of salt; notice the curdy precipitate (soap). Filter off this precipitate, dissolve it in some fresh water and boil down some of the filtrate. Note any change in color or odor and finally when quite concentrated pour a few drops of the thick liquid on a platinum foil, add bisulphate of potassium, evaporate to dryness and ignite gently. Note the odor and blackening; what does it suggest? (Odor of frying fat.) What are the white crystals?

B. Acidify another portion of the dissolved soap with dilute sulphuric acid and note the curdy precipitate, which is insoluble in water but soluble in warm alcohol, (fatty acids), boil the mixture until clear, filter and reserve for future use.

C. Add a solution of lime-water to another portion of the soap solution and notice the greasy precipitate, which is insoluble in warm water and alcohol (lime soap, produced by hard water).

6. Test the solubility of the fatty acids prepared in experiment 5 B with alcohol, and sodium carbonate solution.

7. Introduce small portions of fat into separate tubes containing water and alcohol, warm gently and note the result.

8. *Emulsification Experiments.*—Shake together a few centimeters of cod-liver oil and dilute sodium carbonate.

Notice the resulting white mass which is called an emulsion; what well known liquid is similar in appearance? Examine two or three drops of this emulsion under the microscope and note the character of the compound.

Repeat the same experiment, using a few drops of olive oil and a solution of albumen.

The phenomena observed in these two experiments throw light upon the digestion of fatty substances.

Heat a small quantity of lard or tallow for some time in an evaporating dish with lead oxide, PbO, and a little water, filter off the watery liquid and evaporate a small quantity on a platinum foil. Note the characteristic odor of acrolein, proving the presence of glycerine.

I. Lard. II. Olive or Cottonseed Oil. III. Tallow.—Determine the melting-point of these four substances by filling 2-ounce medicine vials half full of the liquid fats. Introduce a thermometer and cork in such a way that the bulb of the thermometer is enveloped in the fat. Now chill until the mass becomes solid, lay the bottle in a horizontal position in a warm place and closely watch for the point when the fat just becomes liquid (do not heat too rapidly), and observe the temperature. This is the melting-point.

Tests for Cotton-seed Oils. Becchi's Test.—To 5 cc. of the oil in a test-tube add an equal volume of silver nitrate dissolved in alcohol (1 per cent. solution), close the test-tube and keep it in boiling water for ten to fifteen minutes. A darkening of the mixture indicates cotton-seed oil.

Halphen's Test.—To 5 cc. of the oil in a test-tube add 5 cc. of amyl alcohol and 5 cc. of carbon disulphide containing a little free sulphur. Place the tube in a beaker of cold water and bring the water to a boil and allow the tube to remain for twenty minutes. A red coloration indicates cotton-seed oil. This is a very delicate test.

Preparation of Cold-Made Soap. *Lye.*—Dissolve the contents of one can of Babbitt's potash (1 lb.) in one quart of cold water. This gives a solution of about 40° Bé.

Fat.—Tallow rendered according to directions given on page 43. Heat the fat until it is just liquid and add slowly with constant stirring lye equal in amount to one-half the fat taken. Stir it thoroughly until homogeneous and pour into a shallow pasteboard box. Allow it to stand for at least twenty-four hours, and then test for free fat and free alkali as follows:

For Free Fat.—Shake a few shavings of the soap in a corked test-tube with cold gasoline, filter into a convex glass and evaporate off the gasoline over warm water. A greasy residue indicates unsaponified fat.

For Free Alkali.—Shake a few shavings of the soap in a corked test-tube with warm alcohol (95 per cent.), filter and add to the clear liquid a few drops of phenolphthalein; a red color indicates free alkali.

PROTEIN BODIES.

These compounds always contain carbon, hydrogen,

oxygen and nitrogen, sulphur, sometimes phosphorus, iron, etc. They may be classed as follows :

- Protein bodies
  - Proteids.....
    - Simple..... Albumen, Globulin
    - Derived... Coagulated forms, Acid albumen, Alkali albumen, Albumose, Peptone
    - Compound.. Nucleoproteid
  - Albuminoids: Gelatine, from tissues and bones; Keratin, from hair

Composition of Proteins.—

1. *Determination of Nitrogen as Ammonia.*—Mix some dried albumen with lime and moisten sufficiently to roll into small balls with the fingers. Place two or three of these balls in a dry test-tube, heat and hold in the vapors a piece of moistened red litmus paper, note the result. Let the paper dry and note the change.

2. *Determination of Sulphur as Hydrogen Sulphide.*—Test the fumes with a piece of filter-paper moistened with lead acetate and note the result.

3. *Determination of Hydrogen and Oxygen as Water.*—Observe the condensation of water in the cooler part of the tube.

4. *Determination of Carbon.*—Observe the blackening effect produced by the freeing of the carbon.

Tests on Simple Proteids.—

Preparation of Egg Albumen.—Carefully break a fresh egg, allow the clear white to run into a porcelain dish and set the yolk aside for future use. Cut the white with scissors or grind with glass powder and place a small portion in a wide-mouthed stoppered bottle, add ten volumes of distilled water, shake until it froths and invert over a small casserole of water. When the froth and proteid particles float on the surface, carefully withdraw the cork and allow some of the liquid to mix with the water in the casserole. The liquid will probably be opalescent, due to traces of globulin; if strongly so, filter through cloth, test the fluid with litmus paper and if alkaline neutralize with weak acetic acid (2 per cent.)

Tests.—1. To a small portion of the filtered liquid add strong nitric acid. This forms a white precipitate which turns yellow on heating; now cool and add ammonia—it becomes orange. Compare with spots on the skin or woolen cloth produced with nitric acid.

2. *Millon's Test.*—To a small portion of the solution add Millon's reagent and heat. This forms a white precipitate which turns red on cooling, or gives a red color if only a trace of proteid is present.

3. *Precipitation Tests.*—To seven portions of the solution in separate test-tubes add:

a. Lead acetate.

b. Mercuric chloride.

c. Tannic acid.

d. Alcohol.

e. Acetic acid and potassium ferrocyanide.

f. An excess of dry crystallized ammonium sulphate (shake vigorously).

g. Dry sodium chloride or magnesium sulphate.

In each of the above tests carefully note the character and color of the precipitates.

4. *Coagulation by Heat.*—Heat some of the fluid to boiling and add, drop by drop, very dilute acetic acid as long as a precipitate forms; note that this precipitate does not appear unless the solution is acid. Attempt to filter some of the albumen through a wet filter-paper; prove by one of the above tests that no proteid is in the filtrate. Repeat the above test, using first undiluted egg albumen and second a very dilute solution (1 cc. to 100 cc. of water.)

5. *Heller's Test.*—Place some strong nitric acid in a test-tube and allow a solution of albumen to flow gently down the side of the tube; a white ring of precipitated albumen forms at the junction.

6. To 1 inch of 10 per cent. caustic soda or potash add dilute copper sulphate, drop by drop, until a faint blue color but no precipitate appears in the liquid; now add the proteid solution. A violet color indicates proteid; a pink, peptone.

7. *Metaphosphoric Acid Test.*—To a solution of albumen add a very little cold freshly prepared metaphosphoric acid and note the precipitate formed.

8. *Indiffusibility.*—Place some of the solution in a

dialyzer of parchment paper and suspend the whole in a beaker of distilled water. Test the water subsequently for chlorides with silver nitrate and also for proteids by the biuret test.

GLOBULINS.

Globulin from White of Egg.—Saturate some of the ordinary solution with magnesium sulphate, grinding the mass in a mortar. Observe the precipitate of globulin, filter and test the filtrate for proteid, now pour water through the insoluble mass on the filter and test the extract for proteid. Explain. The yield of globulins obtained from this source is very small.

Globulin from Hemp Seed.—Extract dry, ground hemp seed with 5 per cent. salt solution, heating the mixture gently but not above 50° C.; filter and test the clear filtrate as follows :

1. Heat to coagulating point ; what is it?
2. Add sodium chloride to saturation, filter and test the precipitate with nitric acid.
3. Make the biuret test for proteid on some of the saline solution, and also on the precipitate from No. 2.

Important Properties of Albumens and Globulins.—Albumens are soluble in water and saturated solutions of sodium chloride and magnesium sulphate and insoluble in saturated solution of ammonium sulphate. Globulins are insoluble in water, soluble in weak solutions of sodium chloride (5 to 10 per cent.), insoluble in saturated solutions of sodium chloride, magnesium sulphate, and ammonium sulphate.

Alkali Albumen.—Treat undiluted white of egg with strong alkali, note the clear jelly-like mass which results. Dilute some of this with water and try coagulating by heat, finally exactly neutralize with acetic acid and observe the precipitate of alkali albumen. Test some of this by the biuret test. Weaker solutions of albumen are converted by treating with a few drops of very weak alkali (0.1 per cent.) at 100° F., for some minutes.

Acid Albumen.—Treat undiluted white of egg with concentrated hydrochloric acid and heat, resulting in a beautiful violet-blue solution. Dilute some of this and try the coagulation test; now neutralize with dilute alkali and note the precipitate of acid albumen. Test some of this by the biuret test. Repeat the treatment of white of egg, using strong acetic acid. Also try heating weaker solutions with a very few drops of highly dilute sulphuric acid (0.1 per cent. at 100° F. for some time).

Saturate portions of the solutions of acid and alkali albumen with sodium chloride and record the results.

Fibrin from Blood (a globulin-like substance).—Repeat the tests made on coagulated egg albumen and record the results.

Albumose and Peptone.—The action of pepsin is hydrolytic and produces both albumose and peptone—a case similar to the production of dextrine and glucose from starch.

Preparation of Albumose and Peptone.—Coagulate egg albumen by heat. Place some of the coagulum in four test-tubes and treat as follows:

1. Add water and a very small portion of highly dilute hydrochloric acid (0.2 per cent).
2. Add water and a very small amount of pepsin solution.
3. Add both pepsin and hydrochloric acid.
4. Add a few drops of 10 per cent. salt solution.

Place all four tubes in a beaker of cold water, heat to body temperature and note the time they take to clear; also observe whether the mass swells; finally filter all four and test the clear filtrate by biuret test.

GELATINE.

By prolonged boiling with water, gelatine is produced from collagen, which is a protein occurring in the connective tissue.

Place small pieces of gelatine in contact with cold water and note any change which takes place, then slowly heat the mixture to boiling; does it coagulate? Cool a portion of the liquid; what happens? Test the remainder of the warm solution, divided into seven parts with :

1. Hydrochloric acid.
2. Acetic acid.
3. Alum.
4. Basic acetate of lead.
5. Salt and tannin.
6. Heller's test.
7. Biuret test.

Acid and Alkali Albumen and Gelatine Peptone.—

1. Boil some gelatine for several minutes with dilute hydrochloric acid, cool and note that it does not set.

2. Repeat the test, using alkali in place of acid.

3. Treat some gelatine jelly with 0.2 per cent. hydrochloric acid and pepsin at body temperature, finally testing the liquid for peptone.

TESTS ON MILK.

Use Fresh Milk.—Try the reaction with test-paper. Allow a 6-inch test-tube full of milk to stand quietly for about an hour and note the result. Fill a tall cylinder with milk and determine the specific gravity with a lactometer and record the result. Determine the specific gravity of skimmed milk, then add water until the original gravity is restored. Explain this phenomenon. Is cream lighter or heavier than milk?

Examine a drop of milk under the microscope, add a drop of dilute caustic soda, and re-examine. Heat some milk to boiling; no coagulum appears, only a thin skim.

Pioscope Test.—Place a drop or two of fresh well-mixed milk on the center of the hard rubber disc, cover carefully with the glass plate and compare with the standard scale of colors.

Lactoscope Test.—Use Feser's lactoscope. Fill the pipette with milk, allow it to run into the cylinder. Now cautiously add water, shaking after each addition, until the marks on the cloudy glass rod are just visible through

the liquid, read off and record the percentage of fat at the level of the liquid.

Caseinogen.—Dilute some milk with 10 volumes of water, and carefully neutralize with dilute acetic or hydrochloric acid; no precipitate appears; why? Cautiously add more acid until there is a copious precipitate (caseinogen). This action is hastened by heating to 70° C. Filter through a moist fluted paper, the filtrate should be clear; set aside the precipitate and divide the filtrate into three equal portions, A, B and C.

A. Boil this portion to precipitate lactalbumen, filter, test filtrate for lactose. Try biuret test on the precipitate.

B. Add potassium ferrocyanide and acetic acid, a precipitate of lactalbumen.

C. Test for lactose without removing soluble albumen.

Residue of Casein and Fat on Filter-paper.—Wash with water and then with alcohol and finally treat residue with a mixture of ether and alcohol, filter and evaporate some of the clear liquid; note the greasy residue of butter fat.

Action of Salts.—Sodium chloride or magnesium sulphate: saturate a portion of milk with common salt; note the precipitate of caseinogen and fat floating on the liquid, filter and wash. The washings should run into a separate vessel; to this add an excess of acetic acid to precipitate caseinogen; why does the caseinogen go back into solution?

Clot milk with rennet, using boiled and unboiled milk and note any differences. Curdle milk with the aid of heat (40° C.) and acetic acid, filter, dissolve one portion of the curd in weak caustic soda, and grind the balance in a mortar with lime-water, filter, add rennet to both and heat to body temperature; note the results, especially the action of lime-water.

Test some of the curd with pepsin hydrochloric acid, and heat; note the result.

Salts.—Test the clear filtrate as follows :

1. *Chlorides.*—Add silver nitrate and nitric acid; it gives a white curdy precipitate soluble in ammonia.

2. *Sulphates.*—Add hydrochloric acid and barium chloride; it gives a white crystalline precipitate.

3. *Phosphates.*—Add magnesia mixture; it gives a white crystalline precipitate.

ADDITIONAL TESTS ON MILK.

1. Heat one cup of milk to the boiling-point, boil gently for five minutes, cool to 40° C. and add rennet; note the character and amount of curd.

2. Boil one cup of milk for fifteen to twenty minutes, replacing any liquid lost during evaporation by hot distilled water; cool to 40° C., add rennet, note character and amount of curd.

3. To one cup of milk add 1 to 2 cc. of ammonium oxalate solution (precipitant for lime), boil for two or three minutes, cool to 40° C. and add rennet; note char-

acter and amount of curd, if any ; finally add lime-water equal in bulk to the original milk, warm to 40° and note the result.

4. Note the effect of rennet on separate portions of milk heated to 20°, 30°, 50°, and 80° C.

5. Boil rennet in water and then add to milk ; note the result.

Tabulate the results of the above tests.

Butter-Fats.—Fill a test-tube half full of milk, add half a volume of caustic soda, and a little ether, cork and shake well, then place in a beaker of warm water and allow to remain quiet. In a few minutes note the layer of oil and ether floating on the surface. Remove some of this with a pipette and evaporate at a low heat ; note the butter residue.

Souring.—Place some milk in a wide-mouthed bottle, allow it to stand in a warm place for some days or until sour, filter off the curd and test the filtrate for lactose. Explain the change which has taken place.

Skimmed Milk.—Take a small portion of skimmed milk, try its reaction with litmus paper. If not already alkaline, make so with sodium carbonate and heat to boiling. Note the result. Make another portion acid with hydrochloric acid, heat, and note the result.

To a solution of skimmed milk which is slightly warm add rennet, stir well and allow to remain for some time. Note the peculiar character of the curd; cut the curd and note the thin watery liquid which runs from it (whey).

Collect a sufficient quantity of the whey and test it for soluble proteid (lactalbumen). Further notice the sweet taste of the whey, due to lactose (milk-sugar), and its effect on boiling Fehling's solution.

Butter.—Specific tests.

Melt about a teaspoonful of butter with ten times the volume of warm water, stir the mixture vigorously and then chill it by standing it in ice water. Punch two holes in the cake of solid fat and decant off the liquid. Preserve some of this liquid for a test. Taste a portion. Test with litmus paper. To a small portion of the solution add a few drops of nitrate of silver and note the result. Continue the washing operation two or three times until the final filtrate is quite clear. Note any difference between the first and last filtrates in respect to taste, and test with litmus and silver nitrate. Carefully dry some of the chilled fat between layers of filter-paper. Melt the fat in hot water and filter it through dry paper. Preserve this fat for future work.

Now wash the paper with a very small portion of cold gasoline until a drop of the washings evaporated on paper leaves no greasy stain, dry and note the character of the residue on the filter-paper. Cautiously heat some of the residue in a test-tube with lime; observe the odor produced and hold in the fumes a piece of moistened red litmus paper and note the result.

Place a drop of the butter-fat first on water and then on 95 per cent. alcohol; note whether it floats or sinks in either liquid. Mix a small portion of the fat with

potassium or sodium bisulphate, heat on a platinum foil, and note the peculiar disagreeable odor (acrolein). Compare the odor of this compound with the odor produced by treating glycerine in the same way.

Cheese.—Take a sample of any well-cured cheese, grind some of it in warm water, filter and reserve the residue.

Divide the filtrate into six parts and test as follows :

1. For acidity with litmus paper.
2. For soluble proteid.
3. Neutralize for acid or alkali albumen.
4. For peptone.
5. For soluble mineral matter, *i. e.*, chlorides, sulphates, etc.
6. For ammonia and sulphides.

Now extract the residue several times with the same portion of warm alcohol and test the extract for fatty acids. Again extract the residue with warm ether several times and evaporate some of the clear ethereal liquid over warm water; is the residue greasy?

Divide the extracted residue into two parts and test as follows :

1. For insoluble proteid.
2. Burn to white or gray ash and test for insoluble mineral matter, phosphates, lime, etc.

During the incineration, hold pieces of moistened red litmus and lead acetate paper in the fumes and record the results.

TESTS ON EGGS.

A. **Yolk.**—Place one-half the yolk of a fresh egg in a broad six-inch test-tube, add twice the bulk of ether, cork and shake well, allow the tube to rest until the contents separate into two or more layers, uncork the tube carefully and pour off the upper (ether) layer into a clean, porcelain dish and reserve for further work. Now add another portion of ether to the tube, cork, shake and allow to stand until settled, pour off the clear liquid as before, adding it to the clear ether solution obtained in the first operation. Repeat these washings at least four times or until the residue in the tube is white or nearly so. Dry over hot water and reserve for future test, it is essentially vitellin.

Evaporate the combined ether extracts over warm water-bath (no open flame). When the ether has passed off, note the yellow liquid oil similar to melted butter.

Put a drop or two in water; notice that it does not mix and is oily. Now add two or three drops of concentrated nitric acid to the contents of the dish, and note the change of color. Then add a few drops of water and ammonium thiocyanate; red color indicates iron.

Vitellin.—Test the solubility in water and 10 per cent. salt solution; filter these solutions if any are obtained and test them as follows :

1. Biuret.
2. Heller's or Millon's.

B. See tests under albumen, page 51.

C. *Shell.*—

1. Examine a portion of the shell under the low power of a microscope ; note the physical character. Treat a portion of the shell with dilute silicate of soda solution ; when dry, examine as before. (Silicate of soda is used for preserving eggs).

2. Boil an egg with an unbroken shell for ten minutes with a dilute aqueous solution of any coal-tar dye, cool, carefully remove the shell, note the staining of the coagulated white, and explain.

3. Crush the shell, thoroughly extract with warm water, dissolve the extracted mass with dilute hydrochloric acid, and note the effervescence. Hold in the fumes a drop of lime-water on the end of a glass rod and note the clouding. What gas is formed? Now filter, make slightly alkaline with ammonia, add ammonium oxalate and note the white precipitate of calcium oxalate, insoluble in acetic acid. From the data found, give the composition of the shell and the changes which have taken place.

4. Allow an egg to stand in strong vinegar for several hours, remove, wash in one change of water, and note the peculiar condition of the egg. Examine the acid liquid as in the preceding experiment.

5. Examine equal portions of the yolk and white of egg for sulphur by the lime and lead acetate method given under proteids. Which do you think contains the greater amount of sulphur ?

MUSCLE.

Cut off the exterior of a piece of lean meat, test the interior with litmus paper and note the reaction. Then cut the meat in small pieces with scissors and grind these in a mortar with clean, dry sand. Take one-half of the ground mass and extract in a beaker of cold water, stirring every few minutes. Allow the extraction to proceed for half an hour; while this is proceeding, take the balance of the ground mass and extract with 10 per cent. salt solution, stirring as before. Finally pour off and filter the watery extract; take about one-fourth of the liquid and divide into four parts, testing each as follows:

1. Biuret.
2. Heat.
3. Add crystals of ammonium sulphate to saturation.
4. Boil with a few drops of hydrochloric acid, neutralize with caustic potash, add Fehling's solution and boil; note the result (glycogen, $C_6H_{10}O_5$).

The balance of the solution, three-fourths of the whole, will yield creatin if treated as follows: Boil, filter, to the filtrate add lead acetate as long as a precipitate forms, filter again, through the filtrate pass hydrogen sulphide, filter again, slowly concentrate the filtrate and examine under the microscope—knife-rest crystals.

Saline solution must stand at least one hour (better twenty-four); after standing, pour off the solution of globulins and test as follows:

1. Pour a few drops into a large excess of water,

milky deposit of myosin, soluble in strong salt solution.

2. Heat short of boiling and note the result; cool, and test the liquid with litmus paper.

3. Saturate with salt, precipitate of myosin, filter, dissolve, precipitate in weak salt solution, and make Biuret test.

4. Suspend a crystal of rock salt in the solution and note the result.

Make meat extract by steeping lean meat in cold saline water, gradually heating to a boil and finally under slight pressure. Pour off the liquid, cool, remove the fat, dissolve some of the jelly in warm water and compare with Liebig's or Armour's meat extracts by the following tests:

1. Biuret.

2. Glycogen test.

3. Creatinin, Weyl's test: add a very dilute solution of sodium nitroprusside and, cautiously, caustic soda—ruby-red color.

4. Examine the solid extract under the microscope and note the cubical crystals of salt and knife-rest forms of creatin.

Make a water solution of meat (without washing out the blood), heat to coagulate the proteid and filter. Add a few drops of concentrated nitric acid and evaporate the liquid to dryness; cool and take up with water; if cloudy, filter; divide into five parts and test as follows:

1. For chlorides with nitric acid and silver nitrate—white precipitate.

2. For sulphates with hydrochloric acid and barium chloride—white precipitate.

3. For phosphates with nitric acid and ammonium molybdate—yellow precipitate or color.

4. For calcium with ammonium hydroxide and ammonium oxalate—white precipitate.

5. For iron with hydrochloric acid and ammonium thiocyanate—red color.

Experiments in Cooking Tough Meat.—Cut the meat in cubes weighing about four ounces. Treat one piece in boiling water (one pint) covered and add hot water from time to time to prevent concentration; make this test with and without salt.

Preserve the liquids carefully, evaporate 100 cc. of each for total solids, weigh, ignite off organic matter and weigh mineral residue; test this for potassium, sodium, calcium, magnesium and iron, phosphates, chlorides and sulphates.

Carefully record the physical condition of the pieces of meat; note their palatability.

Treat two pieces of the same meat to cold bath of vinegar and water for twenty-four hours, then cook as before with and without salt. Record results as above.

In using salt, take the best dry salt and determine the weights of various level spoonfuls; use these factors.

Composition of Bone.—Procure raw shin-bones of beef and have them well scraped and sawed into one-inch sections. Treat these sections for two or three hours under slight pressure in a soup digester with the least possible

amount of water. Pass the extract through cheese-cloth, filter into a tall glass cylinder, and allow it to cool.

A. **Tests on the Extracted Bone.—**

1. Dry and examine the bone, comparing its condition before and after treatment.

2. Break the extracted bone into small pieces and char a few of these in a small porcelain dish. Note the disagreeable odor of the fumes evolved in the operation. When these have ceased, allow the mass to cool somewhat and then transfer them to a clean dry, test-tube and cork tightly.

Note.—This material is known as bone-black and is largely used for decolorizing many food products, notably sugar.

3. When the contents of the test-tube are thoroughly cool, pulverize them in a mortar. Test the decolorizing power by placing a portion of the bone-black in a dry filter-paper and passing diluted molasses through it, repeating the operation if necessary and comparing with the unfiltered portion.

4. Ignite another portion of the bone-black on a platinum foil until a white ash is obtained. Dissolve this ash in dilute nitric acid and test for lime and phosphoric acid in the usual manner.

B. **Tests on the Water Extract.—**

1. When thoroughly cool remove the layer of fat and compare with tallow obtained in a previous experiment.

2. Make tests for proteid and gelatine on the balance of the extract.

WHEAT FLOURS.

Four samples to be tested; *viz.*, white bread, baker's, maccaroni and whole wheat flour.

Examine small portions of each under the microscope as in lesson under starch. Make paste, stain with iodine and examine again.

Take twenty-five grams of the sample, mix on a porcelain or glass plate with the least amount of water to make a stiff dough, measure the quantity used and do the mixing with a flexible steel knife. Do not handle the dough with the fingers.

Transfer the masses of dough to four separate pieces of well-washed muslin, taking care to clean the mixing surface and knife thoroughly in each case; tie up the muslin in the form of a bag and wash under a gentle stream of water, manipulating well with the fingers; continue the washing until the liquid runs clear from the bag, and fails to give the test for starch with iodine.

Be careful to collect all the washings in a tall glass beaker or jar—they should amount to from one to one and a half liters. Strain through muslin and stand the filtrate aside in a cool place for settling. Examine the residue with a lens.

Now squeeze out as much water as possible from the bag, untie it and collect and weigh the moist gluten; spread it out in a thin cake and dry it for one hour at 100°–105° C. Cool and weigh the dry gluten.

By this time the contents of the jar should have

settled. Decant off the clear liquid, and test small portions of it for proteid and soluble carbohydrate.

Pour distilled water on the residue and stir up the mixture, allow it to settle and decant as before. Repeat this operation twice, and then collect the residue on balanced filter-papers ; dry and weigh.

This last weight gives the starch and fiber content, but in the case of ordinary wheat flours the latter is so small that it may be neglected.

Note.—In the case of whole wheat flour it is best to pass the sample through a one hundred-mesh sieve, taking the screenings for the determination of starch, gluten, etc.

Determination of Ash.—Incinerate about 5 grams of the sample in a porcelain dish, cool, and moisten the ash with a few drops of concentrated nitric acid. Add water, boil and filter, and test the filtrate (1) for potassium with platinic chloride, and (2) for phosphoric acid with ammonium molybdate.

Rye Flour.—Examine under the microscope as under wheat flour.

Take twenty-five grams of rye flour and pass it successively through screens of forty, sixty, eighty and one hundred mesh, weigh and examine the residue retained by each sieve and also test them for starch with iodine.

Treat the material which has passed the one hundred mesh sieve for the determination of starch, gluten, etc., as described under wheat flours.

Ash a small portion and determine the mineral constituents as under wheat flours.

Corn Meal (Yellow).—Examine under the microscope as before, then test a small portion in a corked test-tube with ether or benzine, shake vigorously and when the upper layer of liquid is clear decant it through a filter-paper and cautiously evaporate the liquid in a clean, dry evaporating dish. Note the character of the residue; what is it?

Treat about twenty-five grams for the determination of starch, proteid, etc., as before.

Make ash determinations as before.

TESTS ON RAW POTATOES.

1. See experiments on starch, page 26 *et seq.*

2. Select a small sound potato, clean well and carefully grate it over a shallow tin dish, and allow a thin stream of water to play upon the grater during the operation. Not more than one quart of water should be used.

3. Pour the gratings and liquid through a muslin strainer into a tall glass jar and allow the contents to settle. Examine some of the material left on the filter with a lens, and finally test it with iodine.

4. When the contents of the jar have settled, draw off some of the clear liquid and test for proteid and soluble carbohydrate.

5. Test the settlings for starch.

6. To preserve these, wash several times with dilute salt solution, drain and dry at a low temperature.

BREAD.

Separate the crumb and crust.

Crust.—Grind the darker portion to a coarse powder, add water, mix thoroughly and boil the mass for some time with more water, cool and filter, divide the filtrate into four parts and test as follows :

1. Add iodine solution and note the result.
2. Observe the taste; explain.
3. Add to Fehling's solution and boil ; note the result.
4. Pour a few drops into strong alcohol.

Crumb.—Test the crumb as follows : to a portion add iodine solution. On another portion make test for insoluble proteid (gluten). Which test is best ?

Burn some crumb to a gray ash in a porcelain dish, cool, digest ash with warm nitric acid and divide into three parts. Test one part for chlorides, another for phosphates with ammonium molybdate, and the remainder for potassium with platinic chloride.

Experiments on Toast.—Grind to powder, treat one teaspoonful (level) with boiling water for five minutes, filter hot, cool and divide liquid into four parts, and test as follows :

1. With iodine solution.
2. With Fehling's solution.
3. With tannic acid.
4. Add a few drops of the cooled liquid to strong alcohol.

Prepared Cereals or "Breakfast Foods."—This classification includes the various commercial preparations of oats, corn, barley, wheat and rice, or mixtures of the same. They are supposed to have undergone some operation of cooking and claim to contain no raw starch. The following general tests will serve to give some idea as to the condition of the material and the presence or absence of the various food principles:

1. Powder the material as finely as possible in a mortar or coffee-mill. Pass the grindings through a one hundred-mesh sieve and examine the screenings and siftings separately under the miscroscope, finally staining with iodine and examining for the presence of unbroken starch grains.

2. Extract a portion of both screenings and siftings with cold water, filter and examine the filtrates separately for dextrine (by precipitation with alcohol and color test with iodine), for glucose or reducing sugars with Fehling's solution, for maltose with phenyl hydrazine (see under glucose).

3. Test portions of the insoluble residue separately for proteid, by the usual tests.

4. *Mineral Matter.*—Incinerate a fresh portion of the screenings in a porcelain dish, cool and extract the mass with water, filtering and testing the filtrate for chlorides, sulphates and phosphates of potassium and sodium.

Now treat the insoluble residue with a little concentrated nitric acid and boil. Cool, dilute with water, filter if necessary and test the clear liquid for phosphates and for calcium.

Vinegar.—Cider or malt vinegar is best for these tests.

1. Make test for acidity with litmus paper.

2. Take 10 cc., dilute to 100 cc. with distilled water, add a few drops of phenolphthalein and titrate with half-normal caustic soda solution as explained in the appendix.

3. Make the usual ethyl acetate test for acetic acid.

4. Distil a small quantity of vinegar diluted with a small quantity of water and test the distillate for acidity and for acetic acid.

5. Boil a small quantity of vinegar in a beaker, replace the liquid lost with boiling water, occasionally hold a piece of blue litmus paper in the vapor, and continue the boiling until the liquid no longer reacts acid. Explain this phenomenon.

6. Evaporate to dryness the liquid from the previous experiment. Note the character and odor of the residue. Incinerate and test the ash in the usual way for sulphates, chlorides and potassium.

7. Filter a sample of highly colored vinegar several times through well-ignited bone-black and observe the loss of color.

8. Add basic acetate of lead to cider vinegar as long as a precipitate appears, filter and observe the character of the filtrate.

9. Note the solvent and the neutralizing action on alkalies and various carbonates, such as soda, chalk, also egg shell, already referred to.

DIGESTIVE FLUIDS AND THEIR ACTION: SALIVA, GASTRIC JUICE, PANCREATIC FLUID.

Saliva.—Examine small quantities of saliva, prepared as previously described, in the following way:

1. Under the microscope.
2. Reaction with litmus paper.
3. Silver nitrate and nitric acid.
4. Barium chloride and hydrochloric acid.
5. Nitric acid and ammonium molybdate.
6. Ferric chloride.
7. Make a portion distinctly acid with acetic acid and note the stringy precipitate of mucin.
8. Millon's reagent.
9. *Action of Saliva on Starch.*—See under dextrine. Also try the action on starch paste of a little saliva made acid with hydrochloric acid and then test with iodine.
10. On other portions of starch solution make comparative tests, first on the saliva with Fehling's solution and with iodine, then with starch paste and saliva mixed, with Fehling's solution, then with dry raw starch and saliva.

Artificial Gastric Juice.—(Pepsin and 0.2 per cent. hydrochloric acid.) Repeat the experiments on small wedge-shaped pieces of hard-boiled white of egg with (1) dilute (0.2 per cent.) hydrochloric acid, (2) pepsin, and (3) pepsin and hydrochloric acid.

Test the action of pepsin hydrochloric acid on milk. Try the action of pepsin solution in the presence of a small quantity of alkali.

Pancreatic Juice.—(Pancreatin and 0.5 per cent. sodium carbonate.) Water solution of pancreas contains amylopsin, trypsin, steapsin and rennin.

1. Make tests on three test-tubes containing small portions of clear starch-paste, using the solution of pancreas and adding 0.2 per cent. hydrochloric acid to the first, 0.5 per cent. sodium carbonate to the second, and making no addition to the third. Warm each test-tube very gently, and carefully test with iodine solution and also with Fehling's solution. Make a fourth test with starch paste but heat the pancreatin solution to boiling before adding it.

2. *Fibrin.*—(Proteid.)—Test small portions of fibrin in three test-tubes with water, 0.2 per cent. hydrochloric acid, and 0.5 per cent. sodium carbonate, adding to each some pancreas solution and warming gently. Avoid overheating. Make tests for peptone and alkali albumen in the usual manner.

3. *Oil.*—Take small portions of olive oil in three test-tubes, add to each a small portion of pancreas solution, shake and allow to stand. Add to the first a little 0.2 per cent. hydrochloric acid, to the second a little 0.5 per cent. sodium carbonate, and make no addition to the third. Cork and shake each tube vigorously and allow to stand for a few minutes, then compare with tube No. 3.

4. *Milk.*—Place milk diluted with 5 volumes of water in a test-tube, and add a few drops of pancreatic extract. Keep at 40° C. for half an hour. The caseinogen is first

curdled and then dissolved, and as this occurs the milk changes from a white to a yellowish color.

Divide the resulting liquid into two portions (*a*) and (*b*).

(*a*) Add dilute acetic acid; do you get a precipitate of caseinogen? Why?

(*b*) On this portion try the Biuret test for the presence of peptones.

Milk-curdling Ferments.—

1. Add a drop or two of brine extract of pancreas prepared for you to 5 cc. of warm milk in a test-tube, and keep at 40° C. Within a few minutes look for a solid coagulum and a separation of whey.

2. Repeat No. 1 but add a grain or less of bicarbonate of soda to the milk. Coagulation should occur just as before, so that this ferment is active in an alkaline solution.

3. Boil the ferment first; its power is destroyed.

FERMENTS.

Action of Ferments and Their Prevention. Yeast. *Temperature Experiments.*—Prepare four six-inch test-tubes with perforated corks, bearing tubes bent in the form of an inverted letter J. Fill three of the tubes with a mixture prepared from one-half a yeast cake, one tablespoonful of molasses and one cup of water. Fill the fourth with the same preparation filtered through absorbent cotton.

Allow tubes Nos. 1 and 4 to stand, while No. 2 is sub-

jected to a temperature of 32° F. (produced by a mixture of pulverized ice and salt) for fifteen minutes. No. 3 is boiled for two or three minutes. Now place the four pieces of apparatus so that the delivery tube of each reaches to the bottom of a test-tube containing about two inches of clear lime-water, and allow them to stand for at least twelve hours in a warm place (70° F).

At the end of this time examine each tube of lime-water first for a precipitate, and second with litmus paper.

Finally examine the liquid in the fermentation tubes, noting its odor and general appearance.

Action of Yeast on Various Foods.—Prepare two solutions of sugar in water as follows:

For the first use equal quantities of granulated sugar and water, for the second take one-fourth of the strong solution and dilute with three volumes of water. Fill two of the fermentation tubes already prepared with two sugar solutions (Nos. 1 and 2). Dissolve one-eighth of a yeast cake in about 30 cc. of milk and pour the mixture into a fermentation tube (No. 3).

Fill a fourth fermentation tube (No. 4) with a mixture of one-eighth of a yeast cake dissolved in thin, clear flour paste. Connect all four of the fermentation tubes with lime-water tubes as before and allow them to stand for twelve hours in a warm place (70° F). Examine the contents of each lime-water and fermentation tube.

Acetous Fermentation.—Make a weak solution of alcohol in water (5 parts of alcohol to 20 parts of water)

and test with litmus paper; if acid neutralize with a weak solution of sodium carbonate and test a small portion with potassium iodide and potassium hydroxide and heat—the odor of iodoform shows the presence of alcohol.

Divide the balance of the solution into two equal parts, pour one into a shallow dish and place the other in a well-corked bottle. After the solutions have stood for a day, test with litmus paper, and also by adding alcohol and warming gently. Note the peculiar odor (ethyl acetate—odor of hard cider) in the first case but not in the latter; explain.

Expose a small quantity of beer to the atmosphere; subsequently examine for acidity with test paper and for acetic acid with alcohol. From the results of these experiments explain why bottled weak alcoholic beverages keep sweet.

ANTISEPTICS. PRESERVATIVES.

Borax.—1. Make a weak solution in water and test the solution with litmus. Add a few drops of hydrochloric acid, dip a strip of turmeric paper in this liquid, remove and dry by steam heat. This may be accomplished by wrapping the paper around the upper part of a test-tube partly filled with water and boiling gently—the paper turns pink on the edges.

2. To a small quantity of powdered borax in a porcelain dish add enough alcohol to moisten and 10 drops of glycerine, mix well with a glass rod and ignite the mass

with a match or Bunsen burner. Note the yellow flame with a green edge, characteristic of borax.

Repeat the same tests on boracic acid, omitting the addition of hydrochloric acid.

Sodium Chloride.—Make the usual test for chlorides with nitric acid and silver nitrate, test for sodium by dipping a clean platinum wire into the salt solution and then holding in the flame of a Bunsen burner—a yellow flame indicates sodium. (To clean the platinum wire, hold it in the flame until all the sodium is burned away). Evaporate a drop of strong salt solution on a slide and study the crystals under the microscope (hopper-shaped crystals).

Salicylic Acid.—Make a solution in water and note the taste, also test a portion by adding a few drops of ferric chloride (violet color).

Formalin or "Formaldehyde."—1. To a little concentrated sulphuric acid in a test-tube add a few drops of ferric chloride, cool and add a drop or two of formalin—gives a reddish violet color.

2. To a drop or two of dilute formalin add a dilute solution of phenol (carbolic acid). Pour the mixture carefully upon a little concentrated sulphuric acid—gives a color reaction.

Acetic Acid.—Same as given on page 72.

Cresol.—Place a few drops of molybdic acid dissolved in sulphuric acid on a white porcelain surface, then add a

drop of the solution to be tested. Cresol, if pure, gives a reddish brown tint.

Note.—The above are non-poisonous; the following poisonous:

Mercuric Chloride.—1. To a solution of mercuric chloride add a solution of stannous chloride—gives a white precipitate which turns black on standing.

2. To a solution of mercuric chloride add a solution of potassium iodide—gives characteristic color reaction.

Ferrous Sulphate.—Dissolve a crystal of ferrous sulphate in cold water and add a solution of potassium ferricyanide—blue.

Potassium Permanganate.—1. Characteristic color is violet.

2. To a little potassium permanganate solution add a hot solution of oxalic acid containing a little sulphuric acid—the color is destroyed.

Carbolic Acid.—Note its characteristic odor, also look for yellow color with (1) nitric acid, (2) white precipitate with bromine water.

Action of Alkalies and Vegetable Acids on Metals and their Oxides (Copper, Zinc, Iron, Lead, Tin, Aluminum and Arsenic). *Note.*—Use caustic soda or potash for the representative alkali, acetic and tartaric or citric acids for the acid. Each student is expected to make a tabular statement of the results of the following tests:

Copper.—Treat bright strips of metallic copper for a few minutes with a few cubic centimeters of (1) tartaric acid, (2) acetic acid, (3) caustic potash. Allow these to stand in the cold and note the change if any, then gently heat each to boiling. Pour off the liquid and test for material in solution. The presence of copper will be shown by a blue color which will be intensified by adding a few drops of ammonia. Now heat the strips of copper in the flame until they are coated with a deposit of oxide and then repeat the same tests.

Zinc.—Repeat the above tests on clean and tarnished zinc as far as the action of acids and alkali is concerned. Zinc in solution is indicated by a copious precipitate with potassium ferrocyanide.

Iron.—Treat bright and tarnished iron with the above designated acids and alkali, pour off the solutions (dividing each into two parts) and test with (1) tannic acid, (2) potassium ferrocyanide.

Lead.—Treat bright and tarnished lead with the same acids and alkali, pour off the solutions and test each with (1) hydrogen sulphide, (2) potassium iodide.

Tin.—Repeat the same experiment on bright and tarnished tin and test the solutions with mercuric chloride.

Aluminum.—Treat one or two pieces of aluminum foil with the above-named acids and alkali, pour off the solutions, note the peculiar puckering taste acquired by the acid solutions and the gas evolved by the alkali (try

to light it.) Make a separate test with a few fragments of aluminum and some dilute nitric acid; note the color and test paper reaction of the gas evolved.

Arsenic.—Arsenic is the most poisonous of the metallic compounds. It may be present in the enamel linings of cooking utensils or even low-grade tinware. The best test is known as Reinsch's test and is conducted as follows :

A small portion of material supposed to contain arsenic is reduced to a fine state of division and gently boiled in a test-tube with concentrated hydrochloric acid and a strip of bright copper; a gray metallic deposit upon the copper may be arsenic, antimony, or mercury. In order to confirm the arsenic, remove the strip, dry carefully and introduce into a small piece of glass tubing. Hold this in a horizontal position over a burner and heat strongly—note the white deposit some distance from the point of heating. Examined under the magnifying glass this will be found to consist of minute octahedral crystals of arsenious oxide, white arsenic, As_2O_3.

BAKING-POWDERS.

Three General Types—Tartrate, Phosphate, Alum.

I. **Tartrates.**—Mixtures of cream of tartar and bicarbonate of soda with starch or lactose filler. Treat a small portion of the powder with water and after the effervescence has ceased test a portion of the liquid for starch with iodine solution and for lactose with Fehling's

solution, boil the remainder of the liquid, cool and filter through fluted paper, and test with litmus paper.

1. Place a few drops of the clear liquid on a slide and allow it to evaporate spontaneously. Examine the cleft rectangular crystals of Rochelle salt.

2. Add another portion of the solution to ammoniacal silver nitrate (prepared by adding weak ammonia to silver nitrate solution until the brown precipitate first formed has almost disappeared), and warm gently—notice the brilliant silver mirror due to the reducing action of the tartrate. Compare with dextrose.

3. Test another portion of the solution by adding one drop of fresh cold solution of ferrous sulphate, one or two drops of peroxide of hydrogen and a large excess of caustic potash—a violet color due to tartrates. Evaporate the balance of the solution in a porcelain evaporating dish, char and gently ignite the residue; note the odor while carbonizing, what does it suggest? Cool, add water and test with litmus paper; note the result.

Note.—Tartrate powders may contain a small amount of bicarbonate of ammonia; to test for this, heat a small portion of the powder in a test-tube with caustic potash solution; observe the odor; or hold a strip of moistened red litmus paper over the mouth of the tube.

II. **Phosphate Powders.**—Calcium hydrogen phosphate, bicarbonate of soda and starch filler. Make a water solution and test for filler as in (I) above. Divide the remainder of the solution into three parts.

1. Make acid with nitric acid, add a few drops to ammonium molybdate and warm—yellow precipitate indicates phosphates.

2. Add ammonium oxalate, and ammonium hydroxide until alkaline, and boil—white precipitate indicates calcium. This would give a yellowish red flame on platinum wire.

3. As these powders frequently contain alum it is necessary to make a test. A portion of the solution placed on a slide and allowed to evaporate spontaneously will yield large truncated octahedra of alum. Probably the best method for the determination of alum is to add a portion of the solution to tincture of logwood diluted with two or three times its volume of water, finally adding an equal quantity of ammonium carbonate. In the presence of alum the liquid is colored lavender or dark blue.

III. **Straight Alum Powder.**—Consists of bicarbonate of soda with potassium, sodium, or ammonium alum, and filler. Make water solution and test for filler as above. Boil the solution, filter and test the filtrate.

1. Tincture of logwood.

2. To a portion add potassium hydroxide, heat, note the odor and reaction with moist litmus paper.

3. Evaporate the balance of the liquid to dryness in a porcelain dish, ignite gently, cool and make flame test on residue.

To make flame test, a piece of platinum wire is moistened with hydrochloric acid and held in the Bunsen

flame until it imparts no color to it. Now heat the wire and dip it into the material while hot, replace in the flame and note the color produced—sodium flame is yellow; potassium, violet; lime, reddish. In the presence of sodium the other colors are invisible unless viewed through blue glass, which cuts out the yellow rays.

Note.—The best method of determining alum in bread or water is the tincture of logwood method.

APPENDIX.

Scheme for the Separation and Detection of the Anions, CO_3, PO_4, SO_4, and Cl and the Cations Fe, Ca, Mg, NH_4, Na and K.

The substance occurring in solid form. In the case of a liquid only the acid need be added.

Treat a small portion of the powder with H_2O and enough HNO_3 to make the solution acid, boiling towards the close of the operation; only a small residue should remain at this point; if otherwise, add a little more acid and boil again; cool and filter, rejecting any residue. The filtrate must be perfectly clear before proceeding with the analysis; if it is not, filter once more. Note whether there is any effervescence when the mixture of water and acid is poured upon the powder; if so, it indicates the presence of carbonates, CO_3. The gas evolved should be passed into clear lime-water, which will cloud if CO_2 is present.

The clear solution is now divided into three parts—A = $^1/_2$, B = $^1/_4$, C = $^1/_4$.

Operation with Solution A $^1/_2$.

Add an equal bulk of ammonium chloride and then ammonium hydroxide (NH_4OH) until distinctly alkaline (odor of ammonia is sufficient); boil the mixture. If any precipitate forms, filter the mixture; wash with one change of water.

Precipitate. Ferric hydroxide, a brown gelatinous mass; dissolve this on the filter by pouring over it a small quantity of hot dilute hydrochloric acid; collect the clear yellow fil-

trate and add to it a few drops of ammonium thiocyanate; a deep blood-red color indicates *iron*.

Filtrate, clear and colorless; while still warm, add ammonium carbonate, shake well, allow the precipitate to settle and cautiously add a little more ammonium carbonate; if no further cloud occurs, enough has been used; now pour the mixture upon a filter and wash with one change of water.

Precipitate. Calcium carbonate, a white granular mass; dissolve this in the least possible quantity of acetic acid on the filter. To the clear colorless solution add ammonium hydroxide until alkaline, and an equal bulk of ammonium oxalate; boil the mixture. A white granular precipitate of calcium oxalate indicates calcium. This should give a red flame on heated platinum wire.

Filtrate, clear and colorless; divide into two equal parts D and E. To D add sodium phosphate and ammonium hydroxide and shake well; if a precipitate does not appear at once, cool the mixture and allow it to stand ten minutes. A white crystalline precipitate indicates magnesium. If magnesia has been found in D, pour E into a clean porcelain dish and evaporate off the liquid. When dry, heat until white fumes (ammonium salts) are no longer evolved. Cool and add a small amount of water, filter, and reject the residue. Add two drops of hydrochloric acid to the clear filtrate, dip in it a clean platinum wire and test in the flame. A yellow color indicates sodium; a violet flame, potassium (both to be viewed through blue glass). Potassium may be present even though the flame is yellow; in this case add to the filtrate a few drops of platinic chloride and shake the mixture. A yellow crystalline precipitate indicates potassium.

Operation with B $^1/_4$.

Make strongly alkaline with potassium or sodium hydroxide, boil and hold a piece of moistened pink litmus paper in the vapor arising from the boiling mass, being careful that none of it is spattered on the paper. The paper turning blue when moist and back again to pink when dry indicates ammonia. Where the quantity is large the odor is distinctive.

Operation with C $^1/_4$.

Divide into three equal portions:

Part I. Add to this a few drops of silver nitrate; a white curdy precipitate of silver chloride, soluble in ammonium hydroxide, indicates *chlorides*.

Part II. Add two drops of hydrochloric acid and a little barium chloride; a white crystalline precipitate of barium sulphate, giving a green flame on heated platinum wire, indicates *sulphates*.

Part III. Add a few drops (not more than 10) to one inch of ammonium molybdate in a 6″ tube. Heat the mixture in boiling water about two minutes. A yellow crystalline precipitate of ammonium phosphomolybdate indicates *phosphates*.

Normal Solutions of Acid and Alkali.

A normal solution is one which contains the hydrogen equivalent of the substance in grams in one liter of solution. For all monobasic acids and alkalies the hydrogen equivalent corresponds with the molecular weight of the compound; for dibasic substances it is one-half of the molecular weight. In similar manner tri- and tetrabasic bodies have hydrogen equivalents corresponding to one-third and one-quarter of their molecular weights.

Normal solutions may be made of one-tenth or one-hundredth of their full strength, either by taking the corresponding fractions of their respective equivalents or by diluting the full normal solutions proportionately; they are known as deci- and centinormal solutions respectively.

To explain the preparation of the normal solutions of acid and alkali, one example from each class will suffice and as hydrochloric acid and caustic soda have the most extensive application, their preparation will be given. Neither the acid nor alkali can be weighed or measured with accuracy, hence it is first necessary to make up solutions of some acid or alkali which can be made exact. Sodium carbonate, whose equivalent is 53, can be obtained of a high degree of purity and may be weighed exactly. It is hardly necessary to make up a large quantity, so that 5.3 grams of pure dry soda are usually weighed accurately, dissolved in the least quantity of water and the resulting solution diluted to exactly 100 cc. at or about 60° F. This constitutes the exact normal soda, 1 cc. of which contains 5.3 milligrams of soda.

Of the hydrochloric acid, 36.5 grams are needed but as it is a volatile liquid and cannot be weighed with any accuracy, it is usual to calculate the volume of the liquid from its specific gravity and weight, and to measure out the result in cubic centimeters, allowing a little for loss. The calculation is simple and is made as follows: Divide the equivalent in grams (36.5) by the specific gravity of the concentrated acid (1.2); this gives 30.4+ as a quotient and is the number of cubic centimeters to be used if the acid were pure, but the strongest acid is only 40 per cent.; hence this quotient must be multiplied by 2.5. ($30.4 \times 2.5 = 76$ cc.) It is safe to take 78-80 cc., adding it to 300 or 400 cc. of distilled water and when cool diluting to exactly one liter. To fix

the strength exactly and make it equivalent to the soda solution proceed as follows: Measure 10 cc. of the soda very exactly with a pipette, run it into a small beaker containing about 100 cc. of distilled water, and add two or three drops of methyl orange solution. Now fill a burette with the acid solution, note the level, and run it, drop by drop with constant stirring, into the soda; stop when the last drop changes the color from yellow to pink which remains even after stirring for some moments. Read the burette and note the number of cubic centimeters, and fractions used; say the quantity is 9.8 cc., indicating that this quantity contains as much acid as should exist in 10 cc.; consequently, 980 cc. of the liquid should be diluted to one liter. If the total amount of acid is less, calculate what bulk it should occupy and dilute accordingly. The acid keeps very well but should be preserved in tightly stoppered glass bottles to prevent evaporation.

The caustic soda is deliquescent and absorbs carbon dioxide, so must be weighed rapidly and approximately, using rather more than the 40 grams required, say 50 grams; this is dissolved in 300 or 400 cc. of water, cooled and diluted to one liter. Now draw off 10 cc. of the normal acid in a pipette, allow it to run into a small beaker containing about 100 cc. of distilled water, and add a few drops of phenolphthalein. Fill a clean, dry burette with the caustic soda, note its level and run it, drop by drop with constant stirring, into the acid solution until a faint but distinct pink tint remains after stirring for some moments. Read off the quantity used, say 9.5 cc., showing the solution to be too strong and requiring dilution as in the case of the acid. After performing this operation the acid and alkali should be correct and 1 cc. of one will exactly neutralize an equal quantity of the other.

To test unknown substances, first determine the body present by qualitative analysis, and then weigh or measure some convenient quantity, dissolve or dilute with distilled water, add the indicator and run in the acid or alkali until the neutral point is reached. Observe the number of cubic centimeters used and multiply each by its value in milligrams of the substance sought and divide the result by the quantity used; multiplying this quotient by 100 will yield per cent.

Value of 1 cc. of normal soda in each of the following:

Acetic acid	0.060
Lactic acid	0.126
Tartaric acid	0.075
Citric acid	0.131
Hydrochloric acid	0.0365
Nitric acid	0.063
Sulphuric acid	0.049
Potassium hydroxide	0.0561
Ammonium hydroxide	0.035

STAINS.

Removal of stains depends on the nature of the fabric and quality of the dye.

I. Fabrics:

1. Silk—most easily damaged.
2. Wool—next.
3. Cotton—least.

II. Dyes:

1. Natural dyes least liable to injury.
2. Artificial dyes (except indigo and alizarine) most susceptible to change.

Caution: Do not put gasoline or ether on a wet fabric.

III. Solvents: 1. Water. 2. Alcohol. 3. Ether. 4. Gasoline.
IV. Absorbents: 1. Talc. 2. Starch. 3. Paper.
V. Detergents: 1. Neutral soda or potash soaps.
VI. Bleaches: 1. Peroxide of hydrogen.
2. Hypochlorites of sodium or potassium.
3. Hyposulphite of sodium.
VII. Neutralizing agents:
1. Ammonia.
2. Oxalic acid or acid oxalate of potassium.
3. Muriatic acid, very dilute.
4. Acetic acid.
Steaming, used when softening old stains or in very delicate fabrics.
VIII. Removal of stains and spots, caused by:
1. Fatty bodies as grease or oil.
Use (*a*) ether, (*b*) gasoline, (*c*) talc, (*d*) starch, (*e*) paper.
2. Fruits: (*a*) Coloring matter.
Use bleaches—salts of lemon (bin-oxalate of potash).
(*b*) Acids. Use dilute ammonia.
3. Mineral matter.
(*a*) Rust.
Use (1) acids (on dyed fabics), (2) oxalic, (3) citric, (4) tartaric.
(*b*) Acids.
Use ammonia.
4. Fungoid growths as mildew.
Use milk of lime and a bleach.
(*a*) Javelle water.
(*b*) Labarraques solution.
(*c*) Peroxide of hydrogen.

(*d*) Sunlight.
(*e*) Milk.

5. Ink. Iron base:
   Use (1) Oxalic acid.
   (2) Salts of lemon.
6. Sugar and gum.
   Use warm water only.
7. Paint and varnish:
   If moist, use gasoline.
   If dry, soften with amyl acetate or pine tar oil and then remove with gasoline.

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